GENERAL ANATOMY,

APPLIED TO

PHYSIOLOGY AND MEDICINE:

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PREFACE BY THE TRANSLATOR.

I COMMENCED the present translation while pursuing the study of medicine in Paris in the winter of 1813—14. It was then my intention to have completed and published it immediately upon my return to the United States; but I learnt in England in the spring following, that a translation of this work was about to appear from the London press. This information induced me to abandon my undertaking, but after waiting more than six years for the appearance of the English edition, and finding from letters received from London, that there was but little if any expectation of its being published there at all, I was led to pursue my original plan and complete the translation which I now offer to the public. In doing this, I was influenced more by the intrinsic value of Bichat's work than by any and every other motive. I was unwilling that so many of my professional brethren should be any longer denied access to this admirable production, because it was in a foreign language, and though I could have wished that another had undertaken the task, yet I was resolved to go through the labour rather than it should not be performed at all.

Some of the writings of Bichat are so well known and so justly appreciated in this country, that it is perhaps unnecessary for me to speak of his merits as an author, or offer an apology for translating the present work. Every thing which he gave to the public bore unequivocal proofs of being the production of a mind of the most original and powerful cast,

and it is impossible to estimate what the influence of his labours might have been upon medical science if a longer career had been permitted to him. As it was, he accomplished much, and as his writings are more known, their influence will be more sensibly felt. His manner of investigating physiological subjects was characteristic of his strong and original mind, and it is difficult to determine which is the most admirable, his acute and accurate reasoning, or his ingenious and well conducted experiments. Nor were these experiments the result of preconceived opinions, he seems to have brought his mind perfectly unbiassed to every subject that he investigated, and to have been guided in every instance by the most rigorous laws of induction. To these high qualifications he added great perspicuity in his arrangement, remarkable purity and beauty of style, and an extensive knowledge of disease, which enabled him to enrich his work with much valuable practical information. It is not pretended, but that his experiments upon living animals may have in some few cases led him to erroneous conclusions, but how numerous were the instances in which he obtained from them the most satisfactory and important information. It has, I know, become fashionable of late to undervalue these experiments, and to deny that any useful application can be made of them. It is no doubt true, that the sufferings which animals sometimes undergo in these experiments, are such as to destroy entirely the order and regularity of all the functions, and of course to prevent us from determining any thing as to these functions in health. This probably was the case with some of the experiments of Magendie on vomiting, and Legallois on the principle of life; but let us not condemn this mode of investigation because it has been sometimes injudiciously employed, let us not forget that the argument is wholly directed against the abuse of it, and that these experiments have

already led to some practical consequences of immense value. Would the carotid artery have ever been tied in a living human subject, if it had not been first ascertained that it could be done with safety in animals?

In translating this work, I have studiously endeavoured to give with precision the meaning of the author, and have, I fear, by this means frequently employed French idiomatic expressions. From the great originality of many parts of the General Anatomy, Bichat found it necessary in some instances to employ new terms, to which there were no corresponding words in our language; in such cases, I have either made use of several, or adopted the term, as one or the other seemed best calculated to render the meaning more clear and exact. A few notes only have been given, and these for the most part for the purpose of explaining what was obscure, rather than of controverting any thing contained in the original. Upon the whole, I trust that this work will be a valuable acquisition to our stock of medical literature, and I shall feel as if my labour has not been in vain, if I shall have been the means of making my countrymen better acquainted with the writings of its illustrious author.

Boston, April, 1822.

PREFACE BY THE AUTHOR.

THE work which I now offer to the public, will appear to them new, I trust, in three points of view; 1st, in the *plan* that has been adopted; 2d, in most of the *facts* which it contains; and 3d, in the *principles* which constitute its doctrine.

1st. The *plan* consists in considering separately and presenting with all their attributes, each of the simple systems, which, by their different combinations, form our organs. The basis of this plan is anatomical, but the details that it embraces belong also to medicine and physiology. It has nothing in common, but the name, with what has been lately advanced upon the anatomy of systems; my Treatise on the Membranes alone gives an outline of it.

2d. The *facts* and observations in this work, in addition to what is already known, form a very numerous series. I shall not give an analysis of them; the reader will supply it, how little soever he may know of works on Anatomy and Physiology. Experiments on living animals, trials with different reagents on organized textures,* dissection, examinations after death, observations upon man in health and disease, these are sources whence I have drawn them, and they are the sources

* I have in this and every other instance translated the French word *tissu* by the English word *texture*. I know many writers have adopted the French term, but I think it unnecessary, to say the least, to employ a foreign word, when one of our own language can be used with quite as much precision. *Tr.*

of nature. I have not, however, neglected authors, those especially who make the science of the animal economy a science of facts and experiments.

I will make but one remark upon the experiments contained in this work; amongst them will be found a series upon the simple textures, which I subjected successively to desiccation, putrefaction, maceration, ebullition, stewing, and to the action of the acids and the alkalies. It will be easily seen, that it was not the object of these experiments to determine the composition, or ascertain the different elements, and consequently give a chemical analysis of simple textures; for this purpose they would have been insufficient; but their object was to establish the distinctive characters of these simple textures, to show that each has a peculiar organization, as each has a peculiar life, and to prove by the different results which they gave, that the division which I have adopted is not speculative, but that it rests upon the diversity of their intimate structure. The different re-agents, which I used, were only to assist me where the scalpel was insufficient, and on this account, therefore, I presume these experiments will have some influence upon Anatomy.

3d. The general *doctrine* of this work has not precisely the character of any of those which have prevailed in medicine. Opposed to that of Boerhaave, it differs from that of Stahl and those authors who, like him, refer every thing in the living economy, to a single principle, purely speculative, ideal, and imaginary, whether designated by the name of *soul*, *vital principle*, or *archeus*. The general doctrine of this work consists in analyzing with precision the properties of living bodies, in showing that every physiological phenomenon is ultimately referable to these properties considered in their natural state; that every pathological phenomenon derives from them augmentation, diminution, or alteration; that every

therapeutic phenomenon has for its principle the restoration of the part to the natural type, from which it has been changed; in determining with precision the cases in which each property is brought into action; in distinguishing accurately in physiology as well as in medicine, that which is derived from one, and that which flows from others; in ascertaining by rigorous induction the natural and morbific phenomena which the animal properties produce, and those which are derived from the organic; and in pointing out when the animal sensibility and contractility are brought into action, and when the organic sensibility and the sensible or insensible contractility. We shall be easily convinced upon reflection, that we cannot precisely estimate the immense influence of the vital properties in the physiological sciences, before we have considered these properties in the point of view in which I have presented them. It will be said, perhaps, that this manner of viewing them is still a theory; I will answer, that it is a theory like that which shows in the physical sciences, gravity, elasticity, affinity, &c. as the primitive principles of the facts observed in these sciences. The relation of these properties as causes to the phenomena as effects, is an axiom so well known in physics, chemistry, astronomy, &c. at the present day, that it is unnecessary to repeat it. If this work establishes an analogous axiom in the physiological sciences, its object will be attained.

GENERAL OBSERVATIONS.

THERE are in nature two classes of beings, two classes of properties, and two classes of sciences. The beings are either organic or inorganic, the properties vital or non-vital, and the sciences physiological or physical. Animals and vegetables are organic—minerals are inorganic. Sensibility and contractility are vital properties; gravity, elasticity, affinity, &c. are non-vital properties. Animal and vegetable physiology, and medicine form the physiological sciences; astronomy, physics, chemistry, &c. are the physical sciences. These two classes of sciences have relation only to different phenomena; there are two other classes that correspond to these, which relate to the internal and external forms of bodies and their description. Botany, anatomy, and zoology, are the sciences of organic bodies; mineralogy, &c. of the inorganic. The first will occupy us, and we shall fix our attention especially upon the relations of living bodies with one another, and their relations with those that do not live.

I. *General remarks upon physiological and physical sciences.*

The differences between these sciences are derived essentially from those existing between the properties

that preside over the phenomena, which are the object of each class of sciences. So immense is the influence of these properties, that they are the principle of all phenomena; whether we examine those of astronomy, of hydraulics, of dynamics, of optics, of acoustics, &c. we shall finally arrive by a connexion of causes to gravity, to elasticity, &c. as the end of our researches. So the vital property is the primum mobile to which we must ascend, whether we consider the phenomena of respiration, of digestion, of secretion, circulation, inflammation, fevers, &c.—In giving existence to every body, nature has imprinted upon it a certain number of properties, that particularly characterize it, and by means of which it contributes in its own manner, to all the phenomena that are developed, succeed, and continually connect themselves in the universe. Cast your eyes upon that which surrounds you; turn them upon objects the most distant; whether, aided by the telescope, they examine those that swim in space, or, armed with the microscope, they enter the world of those, whose minuteness almost evades our view, every where you will find on one side physical properties, on the other vital properties, brought into action; every where you will see inert bodies gravitating upon each other, and reciprocally attracting; living bodies gravitate also, but above all they feel, and possess a motion which they owe only to themselves.

These properties are so inherent in bodies, that we cannot conceive of their existence without them. They constitute their essence and their attribute. To exist and to enjoy them are two things inseparable. Suppose that of a sudden they are deprived of them; instantly all the phenomena of nature cease, and matter alone exists. Chaos was only matter without properties; to create the universe, God endowed it with gravity, elasticity, affinity, &c. and to a part he gave sensibility and contractility.

This mode of considering the vital and physical properties, sufficiently shews, that we cannot ascend above them in our explanations, that they afford the principles, and that these explanations are to be deduced from them as consequences. The physical sciences, as well as the physiological, then, are composed of two things; 1st. the study of phenomena, which are effects; 2d. the research into the connexions that exist between them and the physical or vital properties, which are the causes.

For a long time these sciences have not been so considered; every fact that was observed, was made the subject of a particular hypothesis. Newton was the first to remark, that however variable the physical phenomena were, they could all be referred to a certain number of principles. He analyzed these principles and found that attraction enjoyed the most important place among them. Attracted by each other and by their sun, the planets describe their eternal courses; attracted to the centre of our system, the waters, air, stones, &c. move or tend to move towards it: it is truly a sublime idea, and one that serves as the basis to all the physical sciences. Let us render homage to Newton; he was the first who discovered the secret of the Creator, viz. A simplicity of causes reconciled with a multiplicity of effects.

The epoch of this great man was the most remarkable of human wisdom. Since that period, we have had principles from which we draw facts as consequences. This epoch, so advantageous to the physical sciences, was nothing to the physiological; what do I say? it retarded their progress. Mankind soon saw nothing but attraction and impulse in the vital phenomena.

Boerhaave, though brilliant in genius, suffered himself to be dazzled by a system which misled all the men of learning of his age, and which made a revolution in the physiological sciences, that may be compared to that

effected in the physical, by the vortices of Descartes. The plausibility of the theory and the celebrated name of its author, gave to this revolution an empire, which, though rotten in its foundation, was not easily overthrown.

Stahl, less brilliant than profound, rich in the means that convince, though deficient in those that please, formed for the physiological sciences an epoch more worthy of notice than that of Boerhaave. He perceived the discordance between the physical laws and the functions of animals; this was the first step towards the discovery of the vital laws, but he did not discover them. The soul was to him every thing in the phenomena of life; it was much to neglect attraction and impulse. Stahl perceived that these were not true, but the truth escaped him. Many authors, following his steps, have referred to a single principle, differently denominated by each, all the vital phenomena. This, called the vital principle by Barthez, archeus by Van Helmont, &c. is a speculation that has no more reality than that which would refer to a single principle all the physical phenomena. Among these we know that some are derived from gravity, some from elasticity, others from affinity, &c. The same in the living economy, some are derived from sensibility, others from contractility.

Unknown to the ancients, the laws of life have begun to be understood during the last age only. Stahl had already remarked the tonic motions, but he did not generalize their influence. Haller was engaged particularly with sensibility and irritability; but in limiting one to the nervous system, and the other to the muscular, this great man did not consider them in the correct point of view; he made them almost insulated properties. Vicq d'Azyr changed them into functions in his physiological division and ranked them with ossification, digestion, &c. that is, he confounded the principle with the consequence. Thu you see, notwithstanding the labours of a crowd of

learned men, how much the physiological sciences still differ from the physical. In these, the chemist refers all the phenomena that he observes to affinity: the natural philosopher, in his science, every where sees gravity, elasticity, &c. In the others, we have not as yet ascended, at least in a general manner, from the phenomena to the properties from which they are derived. Digestion, circulation, or the sensations, do not bring the idea of sensibility or contractility to the mind of the physiologist, as the movement of a watch proves to the mechanician that elasticity is the primum mobile of its motion; or as the wheel of a mill or of any machine, which running water sets in motion, proves to the natural philosopher that gravity is the cause. To place upon the same level in this respect these two classes of sciences, it is evidently necessary to form a just idea of vital properties. If their limits are not accurately assigned, we cannot with precision analyze their influence. I shall present here only general considerations on this point, which has been treated sufficiently in my Researches upon Life; what I shall add now will be but as a supplement to what has been explained in that work.

II. *Of vital properties, and their influence upon all the phenomena of the physiological sciences.*

To assign the limits of these properties, we must follow them from bodies that are hardly developed, to those which are the most perfect. In the plants that seem to form the transition from vegetables to animals, you discover only an internal motion that is scarcely real; their growth is as much by the affinity of particles and consequently by juxta-position, as by a true nutrition. But in ascending to vegetables better organized, you see them continually pervaded by fluids, that circulate in numerous capillary canals, which mount, descend, and run in a thousand different directions, according to the state of the forces that regulate them. This continual

motion of fluids is foreign to the physical properties, the vital ones only direct it. Nature has endowed every portion of a vegetable with a faculty of feeling the impression of fluids, with which their fibres are in contact, and of reacting upon them in an insensible manner, to favour their course. The first of these faculties I call organic sensibility, the other, insensible organic contractility. This is very obscure in most vegetables; it is the same in the bones of animals. These two properties govern not only the vegetable circulations, which correspond in some measure to the capillary system of animals, but also the secretion, absorption, and exhalation of vegetables. Remark, in fine, that these bodies have only functions relative to their properties; that all the phenomena that animals derive from properties which they have more than vegetables, as the great circulation and digestion, for which there must be sensible organic contractility; as the sensations, for which there must be animal sensibility; and locomotion, the voice, &c. for which animal contractility is necessary; remark, I say, that these functions are essentially foreign to vegetables, since they have not vital properties to place them in action.

For the same reason the catalogue of their diseases is less extensive. They have not the class of nervous diseases, in which the animal sensibility takes so great a part; they have not those of convulsions or paralysis, which are formed by an augmented or diminished animal contractility; they have not those of fevers, or gastric diseases, which evidently arise from a disorder in the sensible organic contractility. The diseases of vegetables are tumours of various kinds, increased exhalations, marasmus, &c.; they all indicate a derangement in the organic sensibility and in the corresponding insensible contractility.

If we pass from vegetables to animals, we see the lowest of these, the zoophites, receive into a sac, which

is alternately filled and emptied, the aliments that are to nourish them; we see them begin to unite sensible organic contractility or irritability to the properties which they have in common with vegetables, and consequently commence the performance of different functions, digestion in particular.

Thus far the organized bodies live wholly within themselves; they have no relation with that which surrounds them; animal life is wanting in them, or at least if it has commenced in these animo-vegetables, its rudiments are so obscure that we can hardly discover them. But this life begins to display itself in the superior classes, in worms, insects, mollusca, &c. On the one hand, the sensations, and on the other, locomotion, which is inseparable from them, are more or less fully developed. Then the vital properties necessary to the exercise of these new functions, are added to the preceding. Animal sensibility and contractility, obscure in the lower species, become more perfect, as we approach quadrupeds, and locomotion and the sensations become also more extensive. Sensible organic contractility then increases, and in proportion to that, digestion, circulation of the great vessels, &c. which are governed by it, receive a developement which is constantly growing more perfect.

If we strictly examine the immense series of living bodies, we shall see the vital properties gradually augmenting in number and energy, from the lowest of plants to the first of animals, man; we shall see the lowest plants obedient to vital and physical properties; all plants are governed only by these, which, in them, consist of insensible contractility and organic sensibility; the lowest animals begin to add sensible organic contractility to these properties, afterwards animal sensibility and contractility. We know the expression of Linnæus, which he has used to characterize minerals, vegetables, and animals. The following would be more correct: 1st. physical properties

for minerals; 2d. physical properties and organic vital properties, except* sensible contractility, for vegetables; 3d. physical properties, all the organic vital properties, and the animal vital properties, for animals.

Man and the neighbouring species, which are the particular object of our researches, enjoy then evidently, all the vital properties, some of which belong to organic life, the others to animal life. 1st. Organic sensibility and insensible contractility have all the phenomena of the capillary circulation, of secretion, of absorption, exhalation, nutrition, &c. evidently dependant upon them in a state of health. In treating, therefore, of these functions, we must always ascend to these properties. In the state of disease, all the phenomena that suppose a disorder in these functions, are clearly derived from an injury of these properties. Inflammation, formation of pus, induration, resolution, hemorrhage, unnatural augmentation or suppression of secretions; increased exhalation, as in dropsies; diminished, or wholly wanting, as in adhesions; absorption, disordered in some way or other; nutrition, altered more or less, or presenting unnatural phenomena, as in the formation of tumours, cysts, cicatrices, &c.: these are morbid symptoms, that evidently suppose some injury or disorder in these two preceding

* Several plants certainly possess a considerable degree of sensible organic contractility; the mimosa pudica (sensitive plant) is a well known example, though there are several others that enjoy this property to almost as great an extent; particularly the hedysarum gyrans, the oxalis sensitiva, and the berberis vulgaris. "A very remarkable degree of irritability, not exceeded by the sensitive plant, exists in the flowers of the barberry, (berberis vulgaris.) When these are fully expanded, the stamens are found spread out on the inside of the corolla. In this situation, if the inside of the filament be touched with a pin or straw, it instantly contracts and throws the anther violently against the stigma. This fact, which has been particularly described by Dr. Smith, in the English barberry, is not less remarkable and distinct in the American varieties of the shrub." Bigelow's Florula Bostoniensis. *Tr.*

properties. 2d. Sensible organic contractility, which, like the preceding, is not separated from the sensibility of the same nature, governs especially in a state of health, the movements necessary to digestion and the circulation of the great vessels, at least for the red and black blood of the general system, for the excretion of urine, &c. In the state of disease, all the phenomena of vomiting, of diarrhœas, and a great part of those numberless ones of the pulse, may ultimately be referred to a disorder of the sensible organic contractility. 3d. All the external sensations, those of seeing, hearing, smelling, tasting, and feeling, and the internal, as those of hunger, thirst, &c. are derived in a state of health from the animal sensibility. In disease, what part does not this property perform? pain and its innumerable modifications, itching, smarting, tickling, the sensation of heaviness, weight, lassitude, throbbing, pricking, pulling, &c. &c. are not these only different alterations of animal sensibility? A hundred different words would not express the diversity of painful sensations that morbid affections bring with them. 4th. Animal contractility is the principle of locomotion and the voice; convulsions, spasms, palsies, &c. are derived from an augmentation or diminution of this property. Examine all the physiological and all the pathological phenomena, and you will see that there is no one which cannot be ultimately referred to some one of the properties of which I have just spoken. The undeniable truth of this assertion, brings us to a conclusion not less certain in the treatment of diseases, viz. that every curative method should have for its object the restoration of the altered vital properties to their natural type. Every remedy, which, in local inflammation, does not diminish the augmented organic sensibility; which, in œdema and dropsy, does not increase this weakened property; and which does

not reduce animal contractility in convulsions, and elevate it in paralysis, fails in its object, and is contra-indicated.

To what errors have not mankind been led in the employment and denomination of medicines? They created deobstruents, when the theory of obstruction was in fashion, and incisives, when that of the thickening of the humours prevailed. The expressions of diluents and attenuants, and the ideas that are attached to them, were common before this period. When it was necessary to blunt the acrid particles, they created inviscants, incrassants, &c. Those who saw in diseases only a relaxation or tension of the fibres, the *laxum* and *strictum* as they called it, employed astringents and relaxants. Refrigerant and heating remedies were brought into use by those who had a special regard in diseases to an excess or a deficiency of caloric. The same identical remedies have been employed under different names according to the manner in which they were supposed to act. Deobstruent in one case, relaxant in another, refrigerant in another, the same medicine has been employed with all these different and opposite views; so true is it that the mind of man gropes in the dark, when it is guided only by the wildness of opinion.

There has not been in the materia medica, a general system; this science has been governed by the different theories that have successively predominated in medicine; each has, if I may so express myself, flowed back upon it. Hence the vagueness and uncertainty that it presents at this day. An incoherent assemblage of incoherent opinions, it is perhaps of all the physiological sciences, that which best shows the caprice of the human mind. What do I say? It is not a science for a methodical mind, it is a shapeless assemblage of inaccurate ideas, of observations often puerile, of deceptive remedies, and of formulæ as fantastically conceived as they are tediously

arranged. It has been said that the practice of medicine was disgusting; I add further, that it is not in some respects the study of a reasonable man, when its principles are derived from the greatest part of the works on the materia medica. Take away those medicines, the effect of which is known only by accurate observation, as evacuants, diuretics, sialagogues, anti-spasmodics, &c. those consequently that act upon a particular function; what knowledge have we of the remainder?

It is, without doubt, extremely difficult at present to class remedies according to their modus operandi; but it is undeniable that all have for their object, the restoration of the vital forces to the natural type, from which they have been driven by disease. Since the morbid phenomena may be considered as different alterations of these forces, the action of remedies should also be viewed as the means by which these alterations are to be brought back to the natural type. Upon this principle, each of the properties has its class of appropriate remedies.

1st. We have seen that there is in inflammations an increase of organic sensibility and insensible contractility; diminish then this increase by cataplasms, fomentations, and local baths. In some dropsies, in white-swellings, &c. there is a diminution of these properties; raise them by the application of wine and all those substances that are called tonics. In every species of inflammation, suppuration, tumours of different kinds, ulcers, obstructions; in every alteration of secretion, exhalation, or nutrition, the remedies act peculiarly upon the insensible contractility, to increase, diminish, or alter it in some way. All those that are called resolvents, tonics, stimulants, emollients, &c. act upon this property. Observe, that these remedies are of two kinds: 1st. general; as wine, ferruginous substances, oftentimes the acids, &c.; these re-animate insensible contractility, and give tone to the whole system: 2d. particular; thus this property is

separately excited by nitre in the kidnies, mercury in the salivary glands, &c.

2d. Many remedies act particularly upon the sensible organic contractility; such are emetics, which produce a contraction of the stomach; cathartics, and drastics especially, which create a strong contraction of the intestines. Art does not excite the heart in the same manner as these viscera; we do not artificially increase its movements as we do those of the stomach in gastric diseases. It will, perhaps, hereafter be attempted, especially if it is true that fever may often be a method of cure, and then it will not, I think, be difficult to find the means of effecting it. At other times, we have to diminish sensible organic contractility, and then remedies are employed that act in a manner opposite to the preceding, as in stopping vomitings, in diminishing intestinal irritation, &c.

3d. Animal sensibility has also remedies that are peculiar to it. But they act in two ways—1st. in diminishing pain in the part where it is seated, as different applications upon tumours, obstructions, &c.: 2d. in acting upon the brain that perceives the pain; thus all narcotic preparations, taken internally, remove the sensation of pain, while the cause still subsists. In cancer of an ulcerated uterus, the disease continues its progress with activity, but the prudent physician stupifies the brain so much, that it is incapable of perceiving it. It is essential to distinguish accurately these two actions of remedies upon the animal sensibility. They are totally different from each other.

4th. Medicinal substances have also their influence on animal contractility. Every thing that produces an active excitement on the external surface of the body, as vesicatories, frictions, smarting, &c. tends to re-animate in paralysis this benumbed faculty. All those substances that paralyze the cerebral action, prevent the brain from governing the muscles of animal life; when these mus-

cles, therefore, are convulsively agitated, these substances are true anti-spasmodics.

In presenting these observations, I do not mean to offer a new plan for the materia medica. Medicines are too complicated in their action to be arranged anew, without more reflection than I profess as yet to have bestowed on the subject. Moreover, an inconvenience common to every classification, would here present itself: the same medicine acts often upon many vital properties. An emetic, while it brings into action the sensible organic contractility of the stomach, excites the insensible contractility of the mucous glands, and oftentimes the animal sensibility of the nervous villi. The same observation may be made with regard to the stimulants of the bladder, of the intestines, &c. My only object is to show, that in the action of substances applied to the body to heal it, as in the phenomena of diseases, every thing must be referred to the vital properties, and that their augmentation, diminution, or alteration, are ultimately the invariable object of our curative method.

Some authors have considered diseases only as increased strength or weakness, and have consequently divided medicines into tonics and debilitants. This idea is true in part, but it is false when we generalize it too much. For every vital force there are means proper to raise it when too much diminished, and to lessen it when too much elevated. But tonics and debilitants are certainly not applicable to every case. You would not weaken animal contractility, augmented in convulsions, as you would insensible organic contractility increased in inflammation; neither would you increase them by the same means. The morbid phenomena that organic contractility and animal sensibility experience, are not cured by the same method. There are medicines proper for each vital force. Moreover, it is not only in increase or diminution that the vital forces err, but they are besides

disordered; the different modifications that insensible contractility and organic sensibility can undergo, produce in wounds and ulcers a diversity of suppuration, in glands a diversity of secretion, in exhaling surfaces a diversity of exhalations, &c. It is necessary, therefore, that medicines should not only diminish or increase each of the vital forces, but that they should moreover restore them to the natural modification from which they have been altered.

What I have just said is particularly applicable to the strictum and laxum of many authors, who every where see but these two things. The strictum may be properly applied to inflammation, the laxum to dropsies, &c.; but what have these two states of the organs in common with convulsions, with disorder of the intellect, with epilepsy, with bilious affections, &c.? It is the peculiarity of those who have a general theory in medicine, to endeavour to bend every phenomenon to it. The fault of generalizing too much, has been perhaps more injurious to science, than that of viewing each phenomenon separately.

These observations are, I think, sufficient to show, that every where in the physiological sciences, in the physiology of vegetables and of animals, in pathology, in therapeutics, &c. there are vital laws, that govern the phenomena which are the object of these sciences; and that there is not one of these phenomena that does not flow from these essential and fundamental laws, as from its source.

If I should take a survey of all the divisions of physical sciences, you would see that the physical laws were ultimately the sole principle of all their phenomena; but this is so well known that it is not necessary to do it. I will consider an important subject, and one to which we are naturally led by the preceding observations. I mean, a parallel between physical and vital phenomena, and consequently between physical and physiological sciences.

III. *Characteristics of the vital properties, compared with those of the physical.*

When we consider, on one side, the phenomena which are the object of the physical sciences, and those that are the object of the physiological, we see how immense is the space that separates their nature and their essence. But this difference arises from that which exists between the laws of the one and the other.

Physical laws are constant and invariable; they are subject neither to augmentation or diminution. A stone does not gravitate towards the earth with more force at one time than another; in every case marble has the same elasticity, &c. On the other hand, at every instant, sensibility and contractility are increased, diminished, or altered; they are scarcely ever the same.

It follows, therefore, that the physical phenomena are never variable, that at all periods and under every influence they are the same; they can, consequently, be foreseen, predicted, and calculated. We calculate the fall of a heavy body, the motion of the planets, the course of a river, the ascension of a projectile, &c.: the rule being once found, it is only necessary to make the application to each particular case. Thus heavy bodies fall always in a series of odd numbers; attraction is in the inverse ratio of the square of the distances, &c. On the other hand all the vital functions are susceptible of numerous variations. They are frequently out of their natural state; they defy every kind of calculation, for it would be necessary to have as many rules as there are different cases. It is impossible to foresee, predict, or calculate, any thing with regard to their phenomena; we have only approximations towards them, and even these are often very uncertain.

There are two things in the phenomena of life, 1st. the state of health; 2d. that of disease; hence there are two distinct sciences; physiology considers the pheno-

mena of the first state, pathology those of the second. The history of the phenomena in which the vital forces have their natural type, leads us to consider as a consequence, those phenomena that take place when these forces are altered. But in the physical sciences there is only the first history; the second is never found. Physiology is to the movements of living bodies, what astronomy, dynamics, hydraulics, hydrostatics, &c. are to those of inert ones; but these last have no such correspondent sciences as pathology. There is nothing in the physical sciences that corresponds to therapeutics in the physiological. For the same reason, every idea of medicament is absurd in the physical sciences. The object of a medicament is the restoration of properties to their natural type; but, the physical properties, never losing this type, have of course no need of restoration.

We see then that the peculiar instability of the character of the vital laws is the source of an immense series of phenomena, which form a peculiar order of sciences. What would become of the universe, if the physical laws were subject to the same commotions and the same variations as the vital? Much has been said of the revolutions of the globe, of the changes that the earth has undergone, of the overthrows that ages have gradually brought about, and upon which ages have accumulated without producing others: but you would see these overthrows and these general commotions in nature at every instant, if the physical properties had the same character as the vital.

For the same reason, that the phenomena and laws of the physical and physiological sciences are unlike, the sciences themselves are essentially different. The manner of presenting the facts and of prying into their causes, the experimental art, &c. every thing bears a different stamp; and it is absurd to confound them. As the physical sciences were perfected before the physiolo-

gical, mankind thought that they could illustrate the latter by connecting them with the former; but they have confused them; and this was inevitable, for the application of the physical sciences to physiology, was the explication of the phenomena of living bodies by the laws of the inert. Here then is a false principle, and all the consequences drawn from it must be erroneous. Let us leave to chemistry its affinity, and to physics its elasticity and gravity, and let us employ in physiology only sensibility and contractility; I except, however, those cases where the same organ becomes the seat of vital and physical phenomena, as the eye and the ear, for example. It is on this account, that the general character of this work is wholly different from those on physiology, and even that of the celebrated Haller. The works of Stahl illustrate well the advantage of neglecting all those pretended accessory aids, which overthrow the science in attempting to support it. But as this great physician had not analyzed the vital properties, he could not present their phenomena in their true point of view. Nothing is more vague and indefinite than the words, *vitality*, *vital action*, *vital influx*, &c. when we do not precisely limit their meaning. Suppose that mankind had created some general and vague words, which were to correspond to all the non-vital properties, and which gave no precise or definite ideas; if you were every where to use these terms, if you did not determine that which belonged to gravity, that which depended on affinity, and that which was the result of elasticity, you would never be understood. Let us say as much in regard to the physiological sciences. The art is much indebted to many physicians of Montpellier for having deserted the theory of Boerhaave, and having followed in preference that given by Stahl. But in leaving a bad path, they have taken another so tortuous, that they will never, I think, find its termination.

Ordinary minds, in reading, stop at insulated facts that are presented; they do not embrace, at one view, the principles of the work. Oftentimes the author himself incautiously follows the impression given to a science in the age in which he writes. But the man of genius every where pauses at this impression, which should be henceforth entirely different in physical and physiological works. It is necessary to use a different language; for most of the words that are carried from the physical into the physiological sciences, continually refer to ideas that have no connexion with them. You see the living solids constantly undergoing composition and decomposition, every moment taking and rejecting new substances; on the other hand, inert bodies remain the same, and keep the same constituent principles, until friction and other causes destroy them. So in the elements of inert bodies, there is a constant uniformity, and an invariable identity in their principles, which is known when they have been once analyzed; whilst the principles of the living fluids are so continually changing, that it is necessary that many analyses should be made, under every possible circumstance. We shall see the glands and exhaling surfaces pour out, according to the degree of their vital forces, a great variety of modifications of the same fluid; what do I say? they pour out a variety of fluids really different; for are not the sweat and the urine poured out under one circumstance, and the sweat and the urine under another, two distinct fluids? There are a thousand examples that would incontestably establish this assertion.

It is the nature of vital properties to exhaust themselves; time wastes them. Elevated in the commencement of life, they remain stationary at the adult age, and afterwards are debilitated and become nothing. Prometheus, it is said, having formed some statues of men, snatched fire from heaven to animate them. This fire is

the emblem of the vital properties; while it burns, life is supported; when it is extinguished, it ceases. It is, then, a part of the essence of these properties, to animate matter for a determinate time only; hence there are necessary limits to life. On the other hand, the physical properties, constantly inherent in matter, never abandon it; so that inert bodies have no limits to their existence, but what accident gives to them.

By nutrition the particles of the matter of inanimate bodies pass into living bodies, and vice versa; and we can evidently conceive that this matter has been endowed through an immense series of ages with physical properties. These properties are given to it at the creation, and will leave it only when the world shall end. This matter, in passing into living bodies, in the space that separates these two epochs, a space that immensity only can bound, this matter, I say, becomes possessed, at intervals, of vital properties, which are then united to physical properties. Here, then, is a great difference in matter, with regard to these two kinds of properties; one it enjoys by intermissions only, the other it possesses constantly.

I could add many other considerations, that would still further establish the difference between the physical and vital laws, and consequently between the physical and vital phenomena, and as a consequence from these, the difference of the general character and methods of the physical and physiological sciences. I could show, that inert bodies are formed at hazard, by juxta-position or a combination of their particles, while living bodies, on the contrary, exist in consequence of a certain function, viz. generation; that the first increase in the same manner as they are formed, by juxta-position or the combination of new particles; the others by an internal movement of assimilation, which requires different preliminary functions; these constantly experiencing

composition and decomposition; those remaining always internally in the same condition, undergo no other modifications than such as are derived from chance and the physical laws. The existence of inert bodies ceases as it commenced, by mechanical laws, by friction, or by new combinations; living bodies afford in their natural destruction, a phenomenon as uniform as in their production; they pass suddenly to a new state when life abandons them, and undergo putrefaction, desiccation, &c. which they did not before, because the physical properties being restrained by the vital, could not produce these phenomena; inert bodies, on the other hand, always preserve the same modifications. Though a stone or a metal, when broken or dissolved, ceases to exist, their particles will always be the same. But some authors have already presented a great part of this parallel; let us content ourselves with drawing from it a consequence often deduced from other facts, I mean the difference of the laws that preside over the two classes of functions.

But there is an essential difference between vital and physical properties; I refer to sympathies.

All inert bodies show no communication in their different parts. Though the extremity of a stone, or of a metal, may be altered in any way by chemical dissolution, or by mechanical agents, the other parts are not affected; it is necessary to touch them by a direct action. On the contrary, every thing is so connected and tied together in the living body, that no one part can be disordered in its functions, without being immediately perceived by the rest. All physicians have known the singular consent that exists between our different organs, both in a state of health and disease, but principally in the latter. How easy would be the study of diseases, if they were stripped of every thing derived from sympathy! Who does not know that these complaints often predominate over those that arise from the injury of

the diseased organ? Who does not know that the cause of sleep, of exhalation, of absorption, of secretion, of vomiting, of diarrhœa, of retention of urine, of convulsions, &c. is oftentimes very far from the brain, from the exhalants, from the absorbents, from the glands, from the stomach, from the intestines, from the bladder, from the voluntary muscles, &c.?

How little soever we reflect on the sympathetic phenomena, it will be evident that they are only unnatural developments of vital forces which are called into action in an organ by the influence that it receives from those that have been directly excited. In this view all the systems are dependant upon each other. This important point of doctrine will be treated at so much length, in this work, particularly under the article on the nervous system that it is useless to insist much upon it here.

We shall see sympathies call into action always those vital properties especially that prevail in a system; animal sensibility in the nerves, contractility of the same kind in the voluntary muscles, insensible organic contractility in the involuntary, sensible contractility in the glands, in the serous, mucous, synovial, cutaneous surfaces, &c. We shall see them assume the character of the vital properties of the organs in which they are developed, their progress will be chronic in the bones, cartilages, &c. acute in the muscles, skin, &c. We shall see them observe in the frequency of their development, the laws of nutrition and growth, to appear oftener in the nervous and vascular system of the child, in the pulmonary organs in youth, and in the abdominal contents in adult age. But let us pass to other subjects.

IV. *Of the vital properties and their phenomena, considered in relation to the solids and fluids.*

Every organized body is composed of fluids and of solids. The first are, in one point of view, the materials, and in another the residue of the second. 1st. They

are the materials, for from the aliments which convey through the intestines, the elements of nutrition, even to the interior of the organs where these elements are deposited, they form evidently a part of the chyle and the blood. 2d. They are the residue, for after having remained some time in the organs, these nutritive particles are taken up, enter again into the blood, and afterwards make a part of the secreted fluids, and of those that form cutaneous and mucous exhalations, which are thrown out externally.

There are then fluids for composition and others subservient to decomposition. The solids are the termination of the first, which come from without, and the place from which the second are sent back. The fluids of composition and decomposition are not all insulated; the chyle, the materials that enter by cutaneous absorption, the principles that the lungs draw from the air, &c. are especially of the first kind. The fluids secreted and exhaled upon the mucous and cutaneous surfaces, appear to be exclusively of the second. But the blood is a common centre, in which the elements that enter, and those that go out, circulate together.

This being admitted, let us see what part the fluids and the solids enjoy in the vital phenomena. This must evidently depend on the properties they possess; and in reflecting on the vital properties which we know, it is evident, that every idea of fluidity is foreign to them, that fluidity cannot be the seat of any contraction nor of organic and animal sensibility, &c. I will not speak here of the pretended spontaneous movements of the blood, of the subtle fluids that it contains, according to some authors, and which can on occasion expand or contract it; all this is but an assemblage of vague ideas, that are confirmed by no experiment. Moreover, all the phenomena of the living economy show us manifestly the fluids in a state almost passive, and the solids, on the

other hand, always essentially active. It is the solids that every where receive the excitement, and act in consequence; the fluids are only the excitants. This constant impression of the second upon the first, constitutes every where continual sensations that are not referred to the brain, and which are consequently not perceived; this is organic sensibility, and differs from the animal in this, that the mind has no consciousness of these sensations, which do not go beyond the organs in which they take place.

Since, on one side, the vital properties are essentially seated in the solids, and on the other, the morbid phenomena are but alterations of these properties, it is evident that these phenomena reside especially in the solids, and that to a certain limit the fluids are foreign to them. Every kind of pain, all spasms and irregular movements of the heart, that constitute the innumerable variations of the pulse, have their seat in the solids.

Let us not believe, however, that the fluids are nothing in diseases; they oftentimes carry the fatal principle of them. They possess, then, in disease, the same place as in the state of health, in which the solids are the active agents of all the phenomena that we observe, but their action is inseparable from that of the fluids. That the heart may contract, that the capillary system may close itself, it is necessary that fluids should first go there. In proportion as the fluids are in their natural state, the excitement is natural; but when this is changed from any cause, as by the introduction of foreign substances, at that instant they become unnatural excitants; the functions are disordered, and diseases supervene. You see, then, that the fluids can oftentimes be the principle of diseases, and the vehicle of morbific matter. But this subject merits further consideration.

Here we can apply the distinction of fluids into those of composition and those of decomposition. The first,

which enter the system in various ways, go into the blood, which, on one account, belongs to them, but on another, to the fluids of decomposition. It is incontestable, 1st. that the chyle can be loaded with a variety of foreign substances, and carry into the blood the fatal principles of disease, as when putrid and badly digested matter, principles of contagion mixed with our aliment, &c. are found in the primæ viæ. 2d. Is it not established by many proofs, that cutaneous absorption oftentimes introduces into the blood the causes of disease, and, 3dly. that substances foreign to the constituent principles of the air, and adapted to excite disease, may accidentally get into that fluid through the medium of the lungs? these things we cannot doubt. Here, then, there are already three ways open to the principles of morbific matter, as we shall moreover have reason to be convinced in the course of this work. 4th. There is another accidental one, that arises from wounds, cuts, bites, lacerations, &c. by means of which destructive principles are oftentimes conveyed into the animal economy. Under these four we might produce a variety of cases, in which the fluids are the first causes of diseases, by conveying their essential principles and becoming unnatural excitants to the solids, in which they produce phenomena contrary to the natural order. But it is evident, that it is those fluids especially destined to the composition of the organs that thus carry morbific principles; these are especially their vehicle, and convey the disease. On the other hand, the fluids destined to the decomposition tend to carry the disease out of the system. We have seen that these fluids are every where poured upon the mucous and cutaneous surfaces, either by exhalation or secretion, as the sweat, the urine, &c.: and it is by these fluids that a crisis is produced. Physicians have exaggerated to an infinite degree the influence of these morbific humours, thus driven out; but we cannot doubt that this doctrine

has oftentimes a real foundation. If these fluids are sometimes the vehicles of disease, it is when they enter unnaturally into the system, as when the bile passes into the mass of blood, when the absorbed urine enters this fluid, &c.

After all that has just been said, it is evident, that it is necessary to distinguish accurately diseases themselves, or rather the whole of the symptoms that characterize them, according to the principles that produce or support them. Almost all the symptoms are in the solids, but the cause can be in them as well as in the fluids. An example will render this more clear; the heart can contract unnaturally; 1st. because its organic sensibility is increased whilst the blood itself remains the same; 2d. because the blood is either augmented, as in plethora, or altered in its nature, as in putrid fevers, &c. while the organic sensibility of the heart does not vary. The excitement may be double, or the organ may be twice as susceptible as common, the effect is the same; an acceleration of the pulse takes place. The solid always takes the principal part in the disease; it is always that which contracts, but in the first case the cause was in the solid, in the second it was not.

This example gives an idea of what occurs in diseases, in all of which the solids are especially in action; but the cause of this action, sometimes exists in them, and sometimes not. It is no doubt essentially necessary to seek the distinction of these cases. The following reflections are made with this view. 1st. I distinguish, in the present question, diseases into two classes; 1st. into those which especially affect animal life; 2d. into those that particularly disorder organic life. I say particularly, for such is the connexion of these two lives, that the one can hardly be altered without the other; thus fevers that affect organic life, produce cerebral effects that agitate the animal: thus also primitive cerebral affections influence sym-

pathetically the circulation, respiration, &c. But certainly we cannot deny, that there are some affections, whose principal and primitive character is a disorder of the animal life; such are convulsions, spasms, paralysis, mania, epilepsy, catalepsy, &c. But it appears that the cause of these diseases is almost always in the solids, and that the fluids most commonly are not affected. Therefore you see that crises, in every case are foreign to these diseases. Hypochondria, hysteria, melancholia, &c. though they appear to reside more particularly in the solids, can yet be in a degree dependant on the fluids, as different examples will prove.

Diseases, on the other hand, that particularly affect organic life, as fevers, inflammations, &c. may have their principle as well in the fluids as in the solids. Hence the reason, that these diseases are subject to crisis, and are cured by evacuants, alteratives, &c.

2dly. It is necessary in order to resolve the question of the affection of the solids or the fluids in diseases, to distinguish their phenomena into those which are sympathetic, and those that are the product of a direct excitement. Every sympathetic phenomenon has its seat essentially and necessarily inherent in the solids. In fine, the solids alone act upon each other and correspond together by means yet unknown. All sympathetic vomiting, febrile agitation of the heart, exhalation, secretion, and absorption, arise from a change effected, by the influence of a part more or less remote, in the solids of those which are the seats of these phenomena. When cold acts upon the skin covered with sweat, immediately the pleura becomes affected. If cold water is conveyed into the stomach while the body is hot, an effect is oftentimes produced upon a distant organ. This is sympathy, and not the repercussion of the humours. In this work I have cited a great number of examples of sympathy under each system;

but in none of them I think is it possible to conceive of an affection of the fluids.

3dly. The division of diseases into organic, or those which alter the texture of the organs, and into those which leave this texture untouched, is still essential here. The first have their seat evidently in the solids.

4thly. The division into acute and chronic, ought not to be neglected in resolving the problem.

5thly. In fine, it would be necessary to make another distinction not less important, viz. that of diseases which are independent of every principle inherent in the economy and of those which proceed from a similar principle, as when the virus of the venereal, the tetters, scrofula or scurvy predominates in the whole system, and alternately attacks the different organs.

How little soever you may examine diseases under different points of view, you will perceive that what is true of one class cannot be so of another. It is evident from this, that it is improper to resolve this question in a general manner, as it has been too often done, and that a theory of diseases founded upon the principle of the affection of the solids or fluids alone, is a pathological absurdity, equal to that in physiology which would place in action the fluids or solids only. I think there are two errors that should be equally feared, that of particularizing and that of generalizing too much. The second leads us to false conclusions as well as the first.

Though the vital properties reside especially in the solids, it is not necessary to consider the fluids as entirely inert. It is undeniable, that those of them which form the composition of the body, increase in vitality as they advance from the aliments of which they are formed, to the solids which they compose. The alimentary mass is less animalized than the chyle, and this is less so than the blood. It would undoubtedly be a subject of very curious research, to determine, how the particles, from being

foreign to the vital properties, and enjoying only physical ones, become by degrees possessed of the rudiments of the first. I say the rudiments, for certainly the vital elaboration that the fluids experience in circulating as such in the body, and before they penetrate the solids to become a part of them, is the first degree of their vital properties. In the same manner, if you should inject into this fluid the materials of those that are exhaled or secreted, the exhalant and secretory organs would repulse these materials, if life had not made them undergo a previous elaboration.

It is evidently impossible to say what this vitality of the fluids is; its existence however is not less real, and the chemist who wishes to analyze the fluids, has, like the anatomist who dissects the solids, only the dead body upon which he can operate. You will observe, that when the principle of life has left the fluids, they go immediately into a state of putrefaction, and are decomposed like the solids, deprived of their vital powers. This alone prevents that internal movement, which undoubtedly enters much into the alterations of which the fluids are susceptible. Observe what takes place after a meal; ordinarily a slight increase of the pulse, the effect of the mixture of the nutritive principles with the blood, is the consequence of it. If you have made use of acrid or spicy aliments, to which you are unaccustomed, a general heat, a thousand different sensations of lassitude and heaviness, accompany digestion. Shall I speak of the various kinds of wine, and their effects, even to intoxication? Who has not a hundred times paid dearly for the pleasures of a repast by a general disorder, an universal agitation, a heat in every part during the whole time that the wine circulates with the blood? Who has not observed that one kind of wine produces one effect and another a different? The solids are then without doubt the seat of every thing we experience; but is not the cause of it in the fluids? It is the blood,

which carrying with its own particles others that are foreign to it, excites all the organs, and especially the brain, because there is a particular relation between this viscus and spirituous liquors, as there is between cantharides and the bladder, and mercury and the salivary glands. That which I say is so true, that if you infuse wine into the open vein of an animal, you will produce analogous effects. The experiments made upon this subject are so well known that I have not even repeated them.

I will relate a fact here which disproves what has lately been advanced upon the incorruptibility of the blood in diseases. A short time since, in examining a body at the Hôtel Dieu, with Mess. Péborde, l'Herminier, and Bourdet, we found instead of the black abdominal blood, a real grey sanies, which filled all the divisions of the splenic vein, the trunk of the vena porta, and all the hepatic branches, so that by cutting the liver in slices, we could distinguish by the flow of this sanies, all the ramifications of the vena porta from those of the vena cava, which contained ordinary blood. This body was so remarkable for its size, that I do not recollect to have ever seen one equal to it. Certainly this sanies was not the effect of death, and the blood had circulated, if not thus altered, at least very different from its natural state, and really decomposed.

Consider the immense influence of aliments upon health, structure, and even character. Compare the people who live only on milk and vegetables with those who are in the constant use of spirituous liquors. See how alkohol, carried into the new world, has modified the manners and habits of the savages; consider the slow and gradual influence of regimen in chronic diseases, and you will perceive that in health, as in disease, the alteration of the fluids is frequently before that of the solids, which consequently become changed; for it is an inevitable

circle. But the alteration of the fluids appears to depend essentially upon the mode of the mixture of parts not animalized with those that are so.

We should have a very inaccurate idea of the mixture with the blood of the foreign substances brought by the way of the intestines, the skin, or the lungs, for the purposes of sanguification, if we compared it to the mixture of inert substances, or chemical combinations. The blood enjoys, if we may so say, the rudiments of organic sensibility; and as the life which it enjoys places it more or less in relation to the fluids that enter it, it is more or less disposed to combine with them and to endow them with the life with which it is animated. Sometimes it repulses for a long time substances that are foreign to it. I am persuaded that a great number of the phenomena that we experience after taking food, especially acrid substances, and spirituous liquors, arises in part from the general disorder that the blood undergoes when its vitality begins to communicate itself to these foreign substances from the kind of struggle which takes place in the vessels, between the living fluid and that which does not live. Thus we see all the solids rise, as it were, against a stimulant they are unaccustomed to. Who knows but that the vitality of the fluids has an influence upon their motions? I think it is very probable. I doubt whether fluids purely inert could, if they were alone in animated vessels, circulate like living fluids. In the same manner, animated fluids could not move themselves, if they were in vessels deprived of life. Life then is equally necessary to one and the other. But these subjects are too obscure to occupy us longer.

V. *Of the properties independent of life.*

These are what I call properties of texture. Foreign to inert bodies, inherent in the organs of living bodies, they arise from their texture, from the arrangement of their particles, but not from the life that animates them.

Thus death does not destroy them. They remain in the organs when life is gone; that, however, adds much to their energy. Putrefaction and the decomposition of the organs, alone destroy them. The two first of these properties are extensibility and contractility of texture. I have explained these sufficiently in my Treatise on Life. I shall have occasion in this work to explain the influence they have in each system. I shall now speak of a property of which as yet very little has been said; which chemists have proved by their experiments, and which physiologists have confounded often with irritability, but which is as distinct from it as it is from the contractility of texture; I mean the property of being* hardened like horn, and contracted by the action of different agents. This will be examined particularly in each system; I shall now describe it in a general manner only.

Every organized part, submitted either after death or during life, to the action of fire and of certain concentrated acids, is contracted and wrinkled in different ways, and is affected almost like irritable organs when they are excited. Now this property is to be considered as to the agents which put it in action, as to the organs which are the seat of it, and as to its phenomena.

1st. Fire is the principal agent of this horny hardening. Every living organ, placed upon burning coals, is suddenly raised to the highest degree. 2d. Next to fire, the strongest acids, the sulphuric first, then the nitric, then the muriatic, make the animal fibres contract most suddenly. As they are diluted, they lose this power, and the acids that are naturally very weak have hardly any of it. 3d. Alkohol is much less powerful in producing this effect, though it may be highly concentrated. It con-

* There are no words in English that correspond exactly to the words *racornir*, and *racornissement*, and I have therefore been compelled to employ the terms, *to harden like horn*, and *horny hardening*, to express the precise meaning. *Tr.*

tracts, however, the texture of parts, which it condenses and even twists. So that those who preserve anatomical specimens, find it necessary to dilute the alkohol. 4th. The neutral salts, after being moistened by the humidity of animal substances, condense and harden them wonderfully after the lapse of a considerable length of time. 5th. When the air has taken away, by drying, the aqueous particles of the solids, these continuing exposed to its action, contract, wrinkle, and twist in a slow and gradual manner. 6th. The alkalies, however strong they may be employed, do not produce any kind of horny hardening. 7th. Water appears to act in a manner opposite to this horny hardening; it dilates, spreads the organs by maceration, and separates their particles. It is when it is combined with much caloric that it produces horny hardening. This phenomenon takes place at some degrees below boiling, and is very remarkable at that point.

The different agents of which I have just spoken, produce, then, two species of horny hardening: 1st. the first is prompt, sudden, almost like the motion which results from the irritation of a living muscle: 2d. the other slow, gradual, and even insensible. Fire and the strong acids are in a special manner the agents of the first. The action of the neutral salts, of the air, of alkohol, principally produce the second.

These two species differ very much in their results. The state to which the first reduces the organ, is soon changed if the hardening cause continues. 1st. Fire continuing to act upon the solids, reduces them to a hard and coaly mass. 2d. Boiling water, after a length of time, destroys by degrees the hardness the solids had suddenly acquired, by being plunged into it. As the hardness diminishes, the effect of the boiling increases, and it arrives at the greatest extent, when the solid, having lost all consistence, becomes pulpy. 3d. Animal organs that have been acted upon suddenly by the acids,

and become consequently hard, soon grow soft and change into a true pulp. This double phenomenon, that is presented on the one hand by boiling, and on the other by the strong acids, has a great analogy, and seems to be derived from the same principle.

The slow and insensible horny hardening, the effect of the contact of neutral salts, such as alum, the muriate of soda, &c. of the air and of alkohol, offers a very different phenomenon from the first. It is not altered by the continued action of the cause that produced it, however long it may be; it does not soften in a slow and insensible manner, as it has hardened, but remains always firm and contracted.

Are these two species only different degrees of the same, or are they derived from separate principles? I know not. I have only observed, that when the living solids have undergone the slow and gradual horny hardening, they are still susceptible of the other. We know that after many years drying, animal textures are hardened, as in a recent state, by the action of fire; I have made the same observation with regard to boiling and the acids. Textures that have been contracted for a long time by alkohol and the neutral salts present the same phenomenon.

All animal textures are susceptible of sudden hardening, except the hair, the epidermis, and the nails; these, if we may so say, exhibit only the rudiments of it. In general the hardening is more sensible, in proportion as the fibrous texture predominates in the organs. Hence the muscles, the tendons, and nerves, are the most susceptible of it. The organs not fibrous, as the glands, show the least degree of it. The slow and insensible horny hardening is almost the same in every part. Both exist in textures deprived of animal contractility, of sensible organic contractility, and of contractility of texture, as well as in those which enjoy them in the highest degree.

Thus the tendons, the aponeuroses, the bones, even when their calcareous substance has been removed by acids, may be hardened as well as the muscles and the skin. This single circumstance would suffice to distinguish the contractility arising from hardening from all others, if a variety of differences, which I shall point out hereafter, under the article of the muscles in particular, did not.

When a texture is suddenly hardened, it loses more than half its length, and becomes twisted in various ways. Taken suddenly from the acid or boiling water, it remains hardened; but if it is pulled, it becomes elongated, and then contracts again, when the force applied ceases, so that it has acquired a real elasticity by the process of hardening. This elasticity is remarkable in the tendons, nerves and muscles, which before this are absolutely destitute of it. This elasticity is not an effect of the slow and insensible hardening of alkohol and the neutral salts. By macerating for a length of time the organized textures, they gradually lose the power of contracting suddenly, which does not, however, entirely disappear, until the maceration has reduced the textures to mere pulp.

If the textures are softened by boiling, and stretched out to their original length, after having been hardened, this cannot be produced again by any agent that we may employ.

When the textures are in a state of putrefaction, they no longer possess this kind of contractility.

Slow and insensible hardening cannot take place during life; this is an insurmountable obstacle to it. But that which is sudden may, when its agents have overcome the resistance that vitality offers. Oftentimes we see the skin hardened by burns. When it is stripped of its epidermis, and a very strong acid is poured upon it, the same effect is produced as upon any other organ.

When a part has been hardened upon a living subject, it almost inevitably dies; it cannot be restored to the

suppleness that it possessed before; suppuration separates it from the sound parts.

The fluids do not present the phenomenon of hardening, the fibrine only excepted. Separated from the blood, it crisps and contracts.

After what has been said, it is evident that the solids possess the faculty of contracting or shortening. This is brought into action in many different ways. During life it appears, 1st. in the influence of the nerves upon the voluntary muscles; this is animal contractility. 2d. In the involuntary muscles by the action of stimuli; this is sensible organic contractility. 3d. In the muscles, the skin, the cellular texture, the arteries, the veins, &c. from a want of extension. This is the contractility of texture, which is not found, or at least is very obscure, in many of the organs, as the nerves, the fibrous bodies, the cartilages, the bones, &c. 4th. By the action of fire, and the strong acids; this is the contractility of the horny hardening, and is general.

When the muscles are deprived of life, they lose the two first kinds of contractility; but the third remains with them as it does with all the organs that enjoy it. When they are dried or remain in water a little time, they lose that also; but the fourth still continues with them; it is the last that abandons the animal textures; it is perpetuated for a length of years. When I have exposed to the action of fire the cartilaginous parenchyma of bones found in cemeteries, they have become hardened. I am persuaded that this faculty would last for many ages, if we could preserve the organic textures.

Contractility is, then, a common and general property, inherent in all animal textures, but which, according to the manner that it is brought into action, presents essential differences, which divide it into many species, that have no analogy. It would certainly be impossible to avoid distinguishing the difference between the four

species I have pointed out, and that insensible contraction, or kind of oscillation, which forms during life the insensible organic contractility, or tonic motions.

Among the causes that bring contractility into action, some belong, then, to life, others are independent of it, and are derived only from organization. All the organs are essentially contractile; but each of the causes which makes them contract acts only upon this or that texture: the horny hardening alone has a general effect.

VI. *Observations upon the organization of animals.*

The properties, whose influence we have just analyzed, are not absolutely inherent in the particles of matter that are the seat of them. They disappear when these scattered particles have lost their organic arrangement. It is to this arrangement that they exclusively belong; let us treat of it here in a general way.

All animals are an assemblage of different organs, which, executing each a function, concur in their own manner, to the preservation of the whole. It is several separate machines in a general one, that constitutes the individual. Now these separate machines are themselves formed by many textures of a very different nature, and which really compose the elements of these organs. Chemistry has its simple bodies, which form, by the combinations of which they are susceptible, the compound bodies; such are caloric, light, hydrogen, oxygen, carbon, azote, phosphorus, &c. In the same way anatomy has its simple textures, which, by their combinations four with four, six with six, eight with eight, &c. make the organs. These textures are, 1st. the cellular; 2d. the nervous of animal life; 3d. the nervous of organic life; 4th. the arterial; 5th. the venous; 6th. the texture of the exhalants; 7th. that of the absorbents and their glands; 8th. the osseous; 9th. the medullary; 10th. the cartilaginous; 11th. the fibrous; 12th. the fibro-cartilaginous; 13th. the muscular of animal life; 14th. the muscular of organic life; 15th.

the mucous; 16th. the serous; 17th. the synovial; 18th. the glandular; 19th. the dermoid; 20th. the epidermoid; 21st. the pilous.

These are the true organized elements of our bodies. Their nature is constantly the same, wherever they are met with. As in chemistry, the simple bodies do not alter, notwithstanding the different compound ones they form. The organized elements of man form the particular object of this work.

The idea of thus considering abstractedly the different simple textures of our bodies, is not the work of the imagination; it rests upon the most substantial foundation, and I think it will have a powerful influence upon physiology as well as practical medicine. Under whatever point of view we examine them, it will be found that they do not resemble each other; it is nature and not science that has drawn the line of distinction between them.

1st. Their forms are every where different; here they are flat, there round. We see the simple textures arranged as membranes, canals, fibrous fasciæ, &c. No one has the same external character with another, considered as to their attributes of thickness or size. These differences of form, however, can only be accidental, and the same texture is sometimes seen under many different appearances; for example, the nervous appears as a membrane in the retina, and as cords in the nerves. This has nothing to do with their nature; it is then from the organization and the properties, that the principal differences should be drawn.

2dly. There is no analogy in the organization of the simple textures. We shall see that this organization results from parts that are common to all, and from those that are peculiar to each; but the common parts are all differently arranged in each texture. Some unite in abundance the cellular texture, the blood vessels and the nerves; in others, one or two of these three common

parts are scarcely evident or entirely wanting. Here there are only the exhalants and absorbents of nutrition; there the vessels are more numerous for other purposes. A capillary net-work, wonderfully multiplied, exists in certain textures, in others this net-work can hardly be demonstrated. As to the peculiar part, which essentially distinguishes the texture, the differences are striking. Colour, thickness, hardness, density, resistance, &c. nothing is similar. Mere inspection is sufficient to show a number of characteristic attributes of each, clearly different from the others. Here is a fibrous arrangement, there a granulated one; here it is lamellated, there circular. Notwithstanding these differences, authors are not agreed as to the limits of the different textures. I have had recourse, in order to leave no doubt upon this point, to the action of different re-agents. I have examined every texture, submitted them to the action of caloric, air, water, the acids, the alkalies, the neutral salts, &c. drying, putrefaction, maceration, boiling, &c. the products of many of these actions have altered in a different manner each kind of texture. Now it will be seen that the results have been almost all different, that in these various changes, each acts in a particular way, each gives results of its own, no one resembling another. There has been considerable inquiry to ascertain whether the arterial coats are fleshy, whether the veins are of an analogous nature, &c. By comparing the results of my experiments upon the different textures, the question is easily resolved. It would seem at first view that all these experiments upon the intimate texture of systems, answer but little purpose; I think however that they have effected an useful object, in fixing with precision the limits of each organized texture; for the nature of these textures being unknown, their difference can be ascertained only by the different results they furnish.

3dly. In giving to each system a different organic arrangement, nature has also endowed them with different properties. You will see in the subsequent part of this work, that what we call *texture* presents degrees infinitely varying, from the muscles, the skin, the cellular membrane, &c. which enjoy it in the highest degree, to the cartilages, the tendons, the bones, &c. which are almost destitute of it. Shall I speak of the vital properties? See the animal sensibility predominant in the nerves, contractility of the same kind particularly marked in the voluntary muscles, sensible organic contractility, forming the peculiar property of the involuntary, insensible contractility and sensibility of the same nature, which is not separated from it more than from the preceding, characterizing especially the glands, the skin, the serous surfaces, &c. &c. See each of these simple textures combining, in different degrees, more or less of these properties, and consequently living with more or less energy.

There is but little difference arising from the number of vital properties they have in common; when these properties exist in many, they take in each a peculiar and distinctive character. This character is chronic, if I may so express myself, in the bones, the cartilages, the tendons, &c.; it is acute in the muscles, the skin, the glands, &c.

Independently of this general difference, each texture has a particular kind of force, of sensibility, &c. Upon this principle rests the whole theory of secretion, of exhalation, of absorption, and of nutrition. The blood is a common reservoir, from which each texture chooses, that which is adapted to its sensibility, to appropriate and keep it, or afterwards reject it.

Much has been said since the time of Bordeu, of the peculiar life of each organ, which is nothing else than that particular character which distinguishes the combination of the vital properties of one organ, from those of another.

Before these properties had been analyzed with exactness and precision, it was clearly impossible to form a correct idea of this peculiar life. From the account I have just given of it, it is evident that the greatest part of the organs being composed of very different simple textures, the idea of a peculiar life can only apply to these simple textures. and not to the organs themselves.

Some examples will render this point of doctrine which is important, more evident. The stomach is composed of the serous, organic muscular, mucous, and of almost all the common textures, as the arterial, the venous, &c. which we can consider separately. Now if you should attempt to describe in a general manner, the peculiar life of the stomach it is evidently impossible that you could give a very precise and exact idea of it. In fact the mucous surface is so different from the serous, and both so different from the muscular, that by associating them together, the whole would be confused. The same is true of the intestines, the bladder, the womb, &c.; if you do not distinguish what belongs to each of the textures that form the compound organs, the term peculiar life will offer nothing but vagueness and uncertainty. This is so true, that oftentimes the same textures alternately belong or are foreign to their organs. The same portion of the peritoneum, for example, enters or does not enter, into the structure of the gastric viscera, according to their fulness or vacuity.

Shall I speak of the pectoral organs? What has the life of the fleshy texture of the heart in common with that of the membrane that surrounds it? Is not the pleura independent of the pulmonary texture? Has this texture nothing in common with the membrane that surrounds the bronchia? Is it not the same with the brain in relation to its membranes, of the different parts of the eye, the ear, &c.?

When we study a function, it is necessary carefully to consider in a general manner, the compound organ that

performs it; but when you wish to know the properties and life of this organ, it is absolutely necessary to decompose it. In the same way, if you would have only general notions of anatomy, you can study each organ as a whole; but it is essential to separate the textures, if you have a desire to analyze with accuracy its intimate structure.

VII. *Consequences of the preceding principles relative to diseases.*

What I have been saying leads to important consequences, as it respects those acute or chronic diseases that are local; for those, which like most fevers, affect almost simultaneously every part, cannot be much elucidated by the anatomy of systems. The first then will engage our attention.

Since diseases are only alterations of the vital properties, and each texture differs from the others in its properties, it is evident there must be a difference also in the diseases. In every organ then, composed of different textures, one may be diseased, while the others remain sound; now this happens in a great many cases; let us take the principal organs, for example.

1st. Nothing is more rare than affections of the mass of the brain; nothing is more common than inflammation of the tunica arachnoides that covers it. 2d. Oftentimes one membrane of the eye only is affected, the others preserving their ordinary degree of vitality. 3d. In convulsions or paralysis of the muscles of the larynx, the mucous surface is unaffected; and on the other hand the muscles perform their functions as usual in catarrhs of this surface. Both these affections are foreign to the cartilages, and vice versa. 4th. We observe a variety of different alterations in the texture of the pericardium, but hardly ever in that of the heart itself; it remains sound while the other is inflamed. The ossification of the common membrane of the red blood does not extend to the neighbouring textures. 5th. When the membrane of the

bronchia is the seat of catarrh, the pleura is hardly affected at all, and reciprocally in pleurisy the first is scarcely ever altered. In peripneumony, when an enormous infiltration in the dead body shows the excessive inflammation that has existed during life in the pulmonary texture, the serous and mucous surfaces often appear not to have been affected. Those who open dead bodies know that they are frequently healthy in incipient phthisis. 6th. We speak of a bad stomach, a weak stomach; this most commonly should be understood as applying to the mucous surface only. Whilst this secretes with difficulty the nutritive juices, without which digestion is impaired, the serous surface exhales as usual its fluid, the muscular coat continues to contract, &c. In ascites, in which the serous surface exhales more lymph than in a natural state, the mucous oftentimes performs its functions perfectly well, &c. 7th. All authors have said much of the inflammation of the stomach, the intestines, the bladder, &c. For myself I believe that this disease rarely ever affects at first the whole of any of these organs, except in the case where poison or some other deleterious substance acts upon them. There are for the mucous surface of the stomach and intestines, acute and chronic catarrhs, for the peritoneum serous inflammations, perhaps even for the layer of organic muscles that separates the two membranes, there is a particular kind of inflammation, though we have as yet hardly any thing certain upon this point; but the stomach, the intestines, and the bladder are not suddenly affected with these three diseases. A diseased texture can affect those near it, but the primitive affection seizes only upon one. I have examined a great number of bodies in which the peritoneum was inflamed either upon the intestines, the stomach, the pelvis, or universally; now very often when this affection is chronic, and almost always when it is acute, the subjacent organs remain sound. I have never seen this membrane exclusively diseased upon one organ,

while that of the neighbouring ones remain untouched; its affection is propagated more or less remotely. I know not why authors have hardly ever spoken of its inflammation, and have placed to the account of the subjacent viscera that which most often belongs only to this. There are almost as many cases of peritonitis as of pleurisy, and yet while these last have been particularly noticed the others are almost entirely overlooked. Oftentimes that part of the peritoneum corresponding to an organ, is much inflamed; we see it in the case of the stomach; we observe especially after the suppression of the lochia or the menses, that it is the portion that lines the pelvis that is first affected. But soon the affection becomes more or less general; at least examinations after death prove it satisfactorily. 8th. Certainly the acute or chronic catarrh of the bladder, or womb even, has nothing in common with the inflammation of that portion of the peritoneum corresponding with these organs. 9th. Every one knows that diseases of the periosteum have oftentimes no connexion with the bone, and vice versa, that frequently the marrow is for a long time affected, while both the others remain sound. There is no doubt that the osseous, medullary and fibrous textures have their peculiar affections which we shall not confound with the idea we may form of the diseases of the bones. The same can be said of the intestines, of the stomach, &c. in relation to their mucous, serous, muscular textures, &c. 10th. Though the muscular and tendinous textures are combined in a muscle, their diseases are very different. 11th. You must not think that the synovial is subject to the same diseases as the ligaments that surround it, &c.

I think the more we observe diseases, and the more we examine bodies, the more we shall be convinced of the necessity of considering local diseases, not under the relation of the compound organs, which are rarely

ever affected as a whole, but under that of their different textures, which are almost always attacked separately.

When the phenomena of diseases are sympathetic, they follow the same laws as when they arise from a direct affection. Much has been said of the sympathies of the stomach, the intestines, the bladder, the lungs, &c. But it is impossible to form an idea of them, if they are referred to the organ as a whole, separate from its different textures. 1st. When in the stomach, the fleshy fibres contract by the influence of another organ and produce vomiting, they alone receive the influence, which is not extended either to the serous or mucous surfaces; if it were, they would be the seat, the one of exhalation, the other of sympathetic exhalation and secretion. 2d. It is certain that when the action of the liver is sympathetically increased, so that it pours out more bile, the portion of peritoneum that covers it does not throw out more serum, because it is not affected by it. It is the same of the kidney, the pancreas, &c. 3d. For the same reason, the gastric organs upon which the peritoneum is spread, do not partake of the sympathetic influences that it experiences. I shall say as much of the lungs in relation to the pleura, the brain in relation to the tunica arachnoides, the heart to the pericardium, &c. 4th. It is undeniable that in all sympathetic convulsions, the fleshy texture is alone affected, and that the tendinous is not so at all. 5th. What has the fibrous membrane of the testicles in common with the sympathies of its peculiar texture? 6th. No doubt a number of sympathetic pains that we refer to the bones, are seated exclusively in the marrow.

I could cite many other examples to prove, that it is not this or that organ which sympathizes as a whole, but only this or that texture in the organs; besides, this is an immediate consequence of the nature of sympathies. In fact the sympathies are but aberrations of the vital properties;

now these properties vary according to each texture; the sympathies of these textures then would do the same.

Observe what takes place in fever, accompanying the different kinds of inflammation. That attending the mucous is slight, that with the serous severe, and that with the cutaneous has the peculiar character of showing itself some days before the eruption, as has been noticed by Pinel. If we attentively observe the fever which attends the inflammations of all the systems, we shall find as many differences, as many peculiar characters, as there are systems. Whence does this arise? From the difference of the relations that unite the heart to each kind of texture; now this difference of relations is the result of the difference of the vital forces peculiar to each.

Observe the itch, herpes, cancer, venereal disease, &c. when they have ceased to be local affections, they spread themselves universally; they alternately attack different textures, according to the relation which they have with the organic sensibility of these textures. But it is almost always separately that they attack them; an organ is never as a whole influenced by them in all its parts. What do I say? If two of these diseases exist at the same time, one seizes upon one texture, the other upon a different one of the same organ. Thus the stomach, the intestines, the lungs, &c. can be attacked by two different diatheses, and each will be independent of the other, because each will be fixed upon a different texture, one upon the mucous, for example, the other upon the serous, &c.

Let us not, however, exaggerate this independence of the textures of the organs in diseases, lest experience should contradict us. We shall see that the cellular system is oftentimes a medium of communication, not only from one texture to another in the same organ, but from one organ to a neighbouring one. Thus in many chronic diseases, all the parts of the same organ are gradually changed, and at the examination of this organ

after death, the whole of it appears to have been affected, though one of its textures only was so at first. In the cancer of the breast, you find at first only a small gland that rolls under the finger; finally the glandular, the cellular, and even the cutaneous textures are confounded in one common cancerous mass. Cancer of the stomach, the intestines, the penis, &c. follows the same course. Observe phthisis, exhibiting in the beginning some small tubercles in the pulmonary texture, at length invading oftentimes the pleura, the bronchial membrane, &c. How little soever you may examine bodies with a view to the same chronic disease, and at different periods, you will be convinced of the truth of this assertion, viz. that a texture being at first affected in an organ, communicates its affection gradually to others, and that you will be deceived in judging of the primitive seat of the disease, if you attempt to determine it from the parts found affected at the time of the examination.

In acute diseases, continuity is oftentimes sufficient to explain the different symptoms that appear in textures that are not affected. The peritoneal coat only being inflamed, vomiting is produced. We cough and sometimes expectorate considerably when the pleura alone is diseased. Delirium comes on when the tunica arachnoides is inflamed, though the intellectual functions are not connected with it. Frequently the diseases of the pericardium are sufficient to disturb the motion of the heart, &c. We cannot deny after this, that oftentimes an alteration in one of the textures alone of an organ is sufficient to disturb the functions of all the others; but still it is in one only, that the primitive source of the evil exists.

I now pass to some other considerations relative to the influence of the anatomy of systems in diseases.

Since every organized texture has every where the same arrangement; since, whatever be its situation, it has the same structure and the same properties, it is

evident that its diseases must be every where the same. It makes no difference, that the serous texture is connected with the brain by the tunica arachnoides, with the lungs by the pleura, with the heart by the pericardium, with the gastric viscera by the peritoneum, &c. every where it is inflamed in the same manner; every where dropsies take place in the same way; every where it is subject to a species of eruption of little whitish tubercles, like the miliary, of which I believe there has been no description, but which deserves great attention; I have already many times observed this peculiar eruption of the serous texture, which is generally of a chronic character, like most of the cutaneous eruptions; I shall speak of it hereafter. Whatever may be the organ that the mucous texture invests, its affections have in general the same character, excepting the difference only that arises from variety of structure. I will say the same of the fibrous, cartilaginous textures, &c. Mr. Pinel appears to me to have done much for the art, in being the first who arranged inflammations in the order of the systems, and embracing in one general view all those of the same system, whatever may be the organs in which it is found.

There are always two orders of symptoms in inflammations; 1st. those that belong to the nature of the diseased textures; 2d. those which depend upon the affected organ, in which the inflammation exists. For example, the kind of pain, the nature of the accompanying fever, the duration, the termination, &c. are almost always the same, whatever serous surface is affected. But difficulty of breathing, dry cough, &c. prove it to be the pleura; diarrhœa, constipation, vomiting, &c. that it is the peritoneum; injury of the intellectual functions, that it is the tunica arachnoides; irregular pulse, that it is the pericardium, &c. The first belong to the whole class, the second set of symptoms is confined exclusively to this or that particular sort; now the second are, if we may so

say, accessory, depending upon the proximity of the affected texture with some other texture. The first are particularly important.

Medicine has yet much to do, in its researches upon the inflammation of the different textures. We are well acquainted with that of the cellular, the cutaneous, the serous, and the mucous; but that of the others is very obscure. It is yet to be ascertained, which is attacked, the fibrous or muscular, in rheumatism. I am inclined to think that it is the first. Almost every thing remains to be known in the cartilaginous, the synovial, the arterial, the venous, &c. as it respects their inflammatory phenomena.

In making these researches, it will be necessary to establish one important distinction; that is, 1st. that certain textures, as the osseous, the muscular of animal life, &c. are precisely the same in all the organs in which they are found, and consequently that their diseases must be the same; 2d. that others, as the cutaneous, the serous, the mucous, &c. experience, according to the organs to which they belong, some variety of structure and vital properties, which necessarily modify the general phenomena of the class of diseases that belong to these textures; 3d. that others, as the glandular, the muscular of organic life, &c. are very different in each organ; and that their general symptoms and class of diseases must consequently differ considerably.

After having shown most of the local diseases, as affecting almost always, not an individual organ, but some texture in an organ, it is necessary to show the differences they present according to the textures they affect. As under each system, this subject will be treated more or less fully, I shall only refer to it here.

We shall see, then, that pain is modified differently in each texture, according to the degree of sensibility that it possesses. No one excites the same sensations as the

others when it is inflamed. Compare the burning of erisypelas with the throbbing of phlegmon, the pain of rheumatism with that of inflamed lymphatic glands, &c. We shall see also that the sense of heat, developed in each inflamed texture, has a particular character; here it is sharp and biting, there like the feeling produced by fire, &c. There are two general causes that produce a variation in the symptoms of diseases: 1st. the nature of the affected texture; thus, as I have just said, the inflammation of each produces a different kind of suffering. 2d. The nature of the disease; we know that cancer, whatever texture it may affect, has a pain that is peculiar to it; that syphilis and scurvy have also a peculiar character, that is, however, modified in a slight degree in each texture.

The difference of textures not only modifies the symptoms, but affects the duration of them also. Nothing in medicine is more vague, in this point of view, than the terms acute and chronic, in relation to inflammations of the different textures. Most commonly they run their course rapidly in the dermoid, cellular, serous, mucous textures, &c.; on the other hand, they are slow in the bones, the cartilages, and the fibro-cartilages. If we apply this distinction to the same texture, it is very well; thus there are catarrhs, serous and cutaneous inflammations, &c. that are acute and chronic. But if we generalize it, it cannot be understood. A catarrh would be chronic if it lasted two months; but this is the common term of an acute inflammation of the bones; a chronic one continues for a whole year or more. Cutaneous, mucous wounds, &c. last only five or six days if they heal by the first intention; while it requires thirty or forty for a bone, a cartilage, &c. to be cicatrized by the juxta-position of its different parts. A disease cannot be classed, then, by its duration, as an acute or chronic one, except in relation to the same system; when we describe it then in a general way, this distinction becomes void.

Physicians consider abstractedly almost all diseases. When they speak of inflammation they describe the redness, swelling, throbbing and pain, as general attributes, always uniform. If of suppuration, they take for a general standard that of the cellular texture, in phlegmon, without thinking that it is only one of the modifications of suppuration and its product. The same may be said of gangrene, scirrhus, &c. Nothing is more vague and uncertain than the general ideas that are given concerning a disease; they scarcely agree in one or two of the textures.

It is not only the history of diseases that the anatomy of systems will elucidate; it will change in part the method of treating morbid anatomy. Morgagni, to whom we owe so much in this respect, and many others, to whom the art is indebted, have adopted the general arrangement used in descriptions. They have examined the diseases of the head, the chest, the abdomen, and the extremities. In following this method, they can only form to themselves a general idea of the alterations common to all the textures. The ideas are necessarily too much contracted, when there is presented only an insulated part of a system, which is composed of a great many others. If, besides this, you obtain a general knowledge of the affections of each system, you must bear in mind, with regard to each, the general ideas concerning the affections of the parts they compose.

It appears to me to be infinitely more simple to consider at first all the affections common to each system, and then to observe what every organ has peculiar to itself in the part that it occupies.

I divide, then, morbid anatomy into two great parts. The first contains the history of the alterations common to each system, whatever may be the organ in the structure of which it is concerned, or whatever may be the place it occupies. It is necessary to show at first the different

alterations of the cellular, arterial, venous, nervous, osseous, muscular, mucous, serous, synovial, glandular, cutaneous textures, &c. to examine the kind of inflammation, suppuration, gangrene, &c. peculiar to each; to speak of the different enlargements of which they are susceptible, the changes in their nature, which they undergo, &c. Some, as the mucous, the cutaneous, the serous, the glandular, &c. afford in this respect an immense field to morbid anatomy. The others, as the fibrous, the nervous, the muscular, &c. are more rarely changed in their texture. We shall see hereafter that nutrition alone is performed in these, and that the others are particularly the seat of exhalation, absorption, secretion, &c. functions which suppose much energy in the insensible contractility and organic sensibility, which are connected with all the alterations of texture.

After having thus pointed out the alterations peculiar to each system, in whatever organ it is found, an examination should be made of the diseases peculiar to each region; as those of the head, the chest, the abdomen, and the extremities, after the common method. Here they may be divided, 1st. into diseases which can especially affect an organ as a whole, and not one of its textures alone, which is very rare. 2d. Into the characters peculiar to each portion of this or that texture; for example in the head, the peculiar symptoms which are seen in diseases of the serous surface of the tunica arachnoides, those in affections of the mucous surface of the pituitary membrane, &c.

This course is incontestably the most natural, though, as in all divisions in which we wish to copy nature, there are many cases which it almost excludes.

It seems to me that we live at a period, when morbid anatomy should take a higher stand. This science is not only that of organic derangements, that take place slowly, as the principles or consequences of chronic diseases,

it consists in the examination of all the alterations our organs can undergo, at any period in which we may observe their diseases. With the exception of certain kinds of fevers and nervous affections, every thing in pathology is within the province of this science. How weak appears the reasoning of many great physicians, when we examine it, not in their works, but on the dead body. Medicine was for a long time excluded from the circle of the exact sciences; it will have a right to be associated with them, at least in the diagnostics of diseases, when we shall every where unite to accurate observation, an examination of the changes our organs undergo. This course is beginning to be that of all rational minds; it will without doubt soon be general. What is observation worth, if we are ignorant of the seat of the disease? You may take notes, for twenty years, from morning to night at the bedside of the sick, upon the diseases of the heart, the lungs, the gastric viscera, &c. and all will be to you only a confusion of symptoms, which, not being united in one point, will necessarily present only a train of incoherent phenomena. Open a few bodies, this obscurity will soon disappear, which observation alone would never have been able to have dissipated.

VIII. *Remarks upon the classification of functions.*

The plan that I have followed in this work, is not the most favourable to the study of the functions. Many of them, such as digestion, respiration, &c. would find no place here, because they do not belong especially to the simple systems, but to a combination of them, an union of many systems, and even of many organs. Thus what I have said upon the functions, is introduced only incidentally in this work, the particular object of which is the analysis of the different simple systems that form the compound organs. However, as some would wish to connect the different facts of physiology that it contains, with a physiological classification, I will now

explain that which I have adopted in my course of lectures.

We know how different the kinds of classification are. The ancient division, into animal, vital, and natural functions, rests upon so weak a foundation, that a methodical superstructure could not be raised upon it. Vicq d'Azyr has substituted one for it which offers hardly any more advantages, as it separates phenomena that are connected, and changes into functions, properties, such as sensibility, irritability, &c. Since this author, others have made divisions which are not more methodical, and are equally removed from the natural arrangement of the phenomena of life.

I have endeavoured, as far as possible, in classing the functions, to follow the path marked out by nature herself. I have laid, in my work upon Life and Death, the foundations of this classification, which I pursued before I published this work. Aristotle, Buffon, &c. have seen in man two kinds of functions, one which connects him with external bodies, the other, which serves for his nourishment. Grimaud brought forward again this idea, which is as great as it is true, in his course of physiology and in his memoir upon nutrition; but by considering it in too general a manner, he did not analyze it with sufficient exactness, he ranked among the external functions, only sensation and motion, he did not describe the brain as the centre of these functions, nor place the voice among them, which is however one of the great means of communication, with the bodies that surround us. He did not analyze more accurately the internal functions. He did not point out their connexion in the elaboration of nutritive matter, where each works in its turn, if I may so express myself; nor show the distinctive characters, which separate generation from all the other functions relating to the individual alone. Besides, the distinction of internal and external functions was only presented as a general sketch in his

Memoir upon Nutrition, and not as a means of classification. He did not avail himself of it, in the division of the functions, in his lectures, of which many manuscripts arranged by himself, are to be met with at the present time; in these he examined, 1st. osteogony, which was treated at much length; 2d. the action of the muscles; 3d. the action of the vessels or the circulation; 4th. generation; 5th. the action of the organs of the senses; 6th. the action of the brain and nerves; 7th. digestion; 8th. secretion; 9th. respiration, &c. From this it may be perceived, that Grimaud, like preceding authors, mixed together all the functions without referring them to certain general heads.

In reflecting upon the division pointed out above, I soon saw that it was not only one of those general views, one of those great outlines, that are oftentimes made by men of genius who cultivate physiology, but that it might become the permanent basis of a methodical classification. To come at this classification I observed that it was necessary at first to refer all the functions to two great classes, one relating to the individual, the other to the species; that these two classes had nothing in common, but the general connexion that unites all the phenomena of living bodies; but a variety of distinctive attributes characterize them, which cannot be separated from them.

These two first classes being rigorously defined, and their limits established by nature, I sought to discover in each, orders equally natural; this was easy in the functions relating to the individual. In fact, this was the place for the general outline of Aristotle and Buffon; but it was not to be presented in too general a manner; the nature and connexion of the functions peculiar to each order, were to be accurately assigned.

I called the order of functions that connects us with external bodies, animal life, thus indicating that this order belongs alone to animals, that it is more with them than with vegetables, and that it is the addition of these func-

tions that particularly distinguishes them from vegetables. I called organic life, the order that serves for the constant composition and decomposition of our bodies, because this life is common to all organized beings, vegetables as well as animals; and because the only condition of enjoying it is organization; so that it forms a boundary between organic and inorganic bodies, as animal life serves to separate the two classes that form the first.

Animal life is composed of the action of the senses which receive impressions, of the brain which perceives them, reflects, and wills, of the voluntary muscles and larynx that execute this volition, and of the nerves which are the agents of transmission. The brain is truly the central organ of this life. Digestion, circulation, respiration, exhalation, absorption, secretion, nutrition, calorification, compose organic life, which has the heart for its principal and central organ.

I place calorification here, because it is evident from what I have said under the article upon the capillary systems, that it is a function analogous to secretion, exhalation and nutrition. It is truly a separation of combined caloric, from the mass of blood. It is, if the expression is preferred, a secretion or exhalation of that fluid in every part of the body. I have not even at present given this place to heat in my physiological classification: but in reflecting upon the method of its production, it will be seen that it ought to have it.

The two orders of the first class being established, it was easy to assign those of the second, which are three in number: 1st. functions belonging to the male; 2d. those belonging to the female; 3d. those arising from an union of the two sexes and the product of this union; these are the three orders.

Such is the classification that I made in my Lectures on Physiology; it has evidently nothing in common with any of those that are found in physiological works; and if you

reflect upon it a little, it will appear I think infinitely preferable to any of them. Observe in fine, that each class and each order have general and characteristic attributes that particularly distinguish them, and which being applicable to all the functions of that order, mark a difference between them and all the functions of any other order. I have pointed out moreover the distinctive attributes of animal and of organic life; I have shown that the organs of one are symmetrical, those of the other irregular; that there is a harmony in the functions of the first, a discordance in those of the second; that one commences sooner and terminates later, &c.

I have demonstrated, that the cerebral nerves belong especially to animal life, the nerves of the ganglions to the organic, which appears to me to be a remarkable difference, and which has induced me to make two systems of the nerves, that anatomists have united in one. The first, belonging to animal life, is composed of the cerebral nerves, the other to organic, is formed of the nerves of the ganglions, or what is commonly called the great sympathetic.

But it is the vital powers especially that distinguish one life from another. I have shown that one kind of sensibility and contractility belongs to animal life, and another to organic. Now as these vital properties are the principle of the functions, it is evident that the division of these properties demonstrates that that of the two lives is not an abstraction, but that it is nature herself that has fixed the limits, since she has made particular properties for each.

It is impossible to form a precise idea of the vital properties, without admitting the division I have made. How many disputes there have been, upon the subject of sensibility! Not one of them would have taken place, if the attributes of animal life had been properly distinguished from those of the organic. Certainly no one will hereafter confound in one view, as frequently has been done,

the faculty that the heart has of being sensible to the entrance of the blood, without transmitting that impression, and the faculty that the skin, the other senses, the nerves, &c. have, not only of feeling the impression of external bodies, but of transmitting it to the brain, so that the sensation may be perceived.

If you include under one common name of irritability, the motions of muscles that contract only by stimuli, and those which the cerebral influence puts in action, it is impossible that you should be understood.

There has been much discussion during the last age, upon the point, whether sensibility is the same as contractility, or if these two properties can be separated. Each of the two opinions seem to have rested upon an equally solid foundation. But all these disputes will be done away, by admitting the distinction I have made in the vital properties. 1st. In animal life, then, it is evident, that contractility is not a necessary consequence of sensibility; thus frequently external objects make for a long time an impression upon us, and yet the voluntary muscles remain unmoved. 2d. On the other hand, in organic life, these two properties are never separated. In the involuntary motions of the heart, the stomach, the intestines, &c. there is first an excitement of the organic sensibility, and then an action of the sensible organic contractility. In the same manner, in the motions necessary to secretion, exhalation, &c. when the organic sensibility has been brought into action, immediately insensible organic contractility takes place. It is that they may be studied better, and appreciated more accurately, that in organic life, I separate these two kinds of contractility from sensibility. In the natural state they are inseparable. Hence why the passive sympathies of animal sensibility are very different from those of animal contractility, and make two distinct classes, whilst the passive sympathies of organic sensibility can never be separated from the

corresponding contractilities. We suffer by sympathy, and are sympathetically convulsed in a distinct manner: these two things are almost always separate. On the contrary, sensation and motion in the organic sympathies are inseparable.

I could prove by many examples, that all the disputes, and all the diversities of opinion, upon the subject of the vital properties, proceed only from this cause, that those which preside over the functions of one life, have not been distinguished from those which put into action the functions of the other.

Let us return to my physiological division; I will now give a table of it, which, presenting it under one point of view, will give a more precise idea of the classification. This table comprehends, 1st. the prolegomena of the science; 2d. the exposition of the functions. In the prolegomena, every thing is referred to two great considerations; on the one hand to organic texture, described in a general manner, and on the other to life, considered in relation to its great attributes.

TABLE OF PHYSIOLOGY.

PROLEGOMENA.

GENERAL OBSERVATIONS ON ORGANIC TEXTURE.

SECTION I.
- 1st. Of the organic texture of animals.
- 2d. Of simple textures, in general.
- 3d. Of organs, in general.
- 4th. Of the apparatus, in general.*

SECTION II.
- 1st. Of the properties of texture.
- 2d. Division of the properties of texture.
  - Extensibility.
  - Contractility . . . .
    - 1st. By want of extension.
    - 2d. By horny hardening.
- 3d. Characters of the properties of texture.

* In a subsequent part of this work, the author defines *appareil*, which I have translated by the word *apparatus*, to be an assemblage of many systems. It will be perceived that the English word in this and some other instances is in the plural number. I should certainly have preferred some other term more conformable to the idiom of our own language if I had known any one that would so well have conveyed the sense of the author. *Tr.*

GENERAL OBSERVATIONS UPON LIFE.

SECTION I.	1st. Of life and its functions.		
	2d. Classification of functions	Of those relating to the individual.	Animal functions.
			Organic functions.
		Of those relating to the species.	Functions of the male.
			Functions of the female.
			Functions relating to the union of the sexes, and the product of this union.
	3d. Of the differences and relations that exist between the two classes of functions.		
	4th. Of the differences and relations that exist between the two orders of the first class.		
	5th. Of the differences and relations that exist between the three orders of the second class.		
SECTION II.	1st. Of the vital properties.		
	2d. Division of the vital properties . .	Animal properties . .	Sensibility.
			Contractility.
		Organic properties . .	Sensibility.
			Sensible and insensible contractility.
	3d. Characters of the vital properties.		
	4th. Of the causes which modify the vital properties		Habit.
			Sex.
			Climate.
			Seasons.
			Age, &c.
	5th. Of the peculiar differences of the vital properties, in each simple texture, in each individual		Of that which is called individual life.
	6th. Of the general differences of the vital properties in different individuals		Of temperament.
			Of the passions.
			Of the character.
	7th. Sympathies of vital properties.		
	8th. Division of sympathies	Animal sympathies . .	Of sensibility.
			Of contractility.
		Organic sympathies . .	Of sensible contractility.
			Of insensible contractility.

OF THE FUNCTIONS.

FIRST CLASS.—FUNCTIONS RELATIVE TO THE INDIVIDUAL.

ORDER FIRST.—*Functions of Animal Life.*

GENUS I. *Sensations.*	1st. Of the general sensations, or feeling,	external. internal.		
	2d. Of particular sensations.	Hearing. Seeing. Smelling. Tasting Feeling.		
	3d. Of pleasure and of pain.			
GENUS II. *Cerebral Functions.*	1st. Relative to sensation	Of perception. Of imagination. Of memory.		
	2d. Relative to the understanding	Of attention. Of the ideas. Of the judgment. Of the reasoning faculty, &c.		
	3d. Relative to motion	Of the will, which is determined by	the judgment. the passions.	Of the opposition of these two causes.
	4th. Connexion of the cerebral functions with life		Of concussion. Of apoplexy, &c.	

- **GENUS III.** *Locomotion.*
  - 1st. Of the immoveable attitudes
    - on the feet . . Standing.
    - on the knees.
    - on the pelvis.
    - on the head, &c. &c.
    - — Prostration.
  - 2d. Motion
    - Of the superior extremities.
      - Prepulsion.
      - Repulsion.
      - Diduction.
      - Pressure.
      - Elevation, &c.
    - Of the inferior extremities.
      - Walking.
      - Running.
      - Leaping.
    - Of the trunk . . Support, raising weights.
    - Of the whole body. Swimming.
    - Of gesture considered as an auxiliary to the voice
      - 1st. Gestures of the face.
      - 2d. Gestures of the head in general.
      - 3d. Gestures of the superior extremities.
- **GENUS IV.** *Voice.*
  - 1st. Of the voice of brutes . . . Dumbness.
  - 2d. Of speech
    - Of stuttering.
    - Of lisping, &c.
  - 3d. Of singing
    - true.
    - false.
  - 4th. Of declamation.
- **GENUS V.** *Nervous transmission.*
  - 1st. Transmission to the brain of sensations
    - general.
    - particular.
  - 2d. Transmission of motion
    - to the locomotive organs.
    - to the vocal organs.
  - 3d. Mode of transmission.

OF THE INTERMISSION OF THE FUNCTIONS OF ANIMAL LIFE.

Sleep.	1st. natural	partial	of the senses.	
			of the brain . . .	Of sympathetic sleep.
			of the muscles.	
		general.		
	2d. unnatural.			
	3d. Dreams and somnambulism.			

ORDER SECOND.—*Functions of organic life.*

GENUS I. *Digestion.*	1st. Of hunger and thirst.		
	2d. Of aliments.		
	3d. Of taking of aliments	solid.	
		fluid.	
	4th. Of mastication, of lubricating with saliva and deglutition.		
	5th. Alteration of the alimentary mass	in the œsophagus.	Action of the liquor of the œsophagus.
		in the stomach .	Action of the gastric liquor.
		in the small intestines . . .	Action of the bile.
			Action of the pancreatic liquor.
			Action of the intestinal liquor.
	6th. Separation of the substances that are nutritive from those that are not.		
	7th. Absorption of the nutritive substance; course of the chyle in	the lacteals.	
		the mesenteric glands.	
		the thoracic duct.	
		the blood vessels.	
	8th. Excretion of the non-nutritive substance . . .	Of the peristaltic motion.	
		Of the fecal matter.	
		Of the intestinal gas.	
	9th. Of vomiting, as it has its seat in	the pharynx and œsophagus.	
		the stomach.	
		the small intestines.	
		the large intestines.	
		— Sympathetic vomiting.	

GENUS II. *Respiration.*	1st. Of the air.		
	2d. Mechanical phenomena	Inspiration.	
		Expiration.	
	3d. Chemical phenomena relative	to the air.	
		to the blood.	
	4th. Connexion of respiration with life.	Of asphyxia, &c.	
GENUS III. *Circulation.*	1st. general	Circulation of red blood.	
		Circulation of black blood.	
		Action of the heart.	
		Action of the arteries.	
		Action of the veins.	
		Connexion of the circulation with life. Of syncope, &c.	
	2d. abdominal.		
	3d. capillary	general	phenomena of the motion of the blood.
			change of red to black.
		pulmonary	its relation with the general.
			change of black to red blood.
GENUS IV. *Exhalations.*	1st. in general	of their agents.	
		of their phenomena.	
		of their alterations.	
		— Sympathetic exhalations.	
	2d. in particular. Exhalations	serous.	
		cellular	of fat.
			of serum.
		synovial	in the grooves of the tendons.
			in the articulations.
		medullary	in the middle of the long bones.
			in the extremities of the long bones, in the short and flat ones.

GENUS V. *Absorptions.*

- 1st. in general
  - Of their agents.
  - Of their phenomena.
  - Of their alterations.
  - — Sympathetic absorptions.
- 2d. in particular. Absorptions
  - serous.
  - cellular
    - of fat.
    - of serum.
  - synovial
    - in the grooves of the tendons.
    - in the articulations.
  - medullary
    - in the middle of the long bones.
    - in the extremities of the long bones, in the short and flat ones.

GENUS VI. *Secretions.*

- 1st. in general
  - Of their agents.
  - Of their phenomena.
  - Of their alterations.
  - — Sympathetic secretions.
- 2d. in particular. Secretions
  - lachrymal.
  - salivary and pancreatic.
  - hepatic.
  - renal.
  - mucous.
  - sebaceous.

GENUS VII. *Nutrition.*

- 1st. Of the double nutritive motion.
- 2d. Composition of organs
  - Nutritive matter, considered in
    - the chyle.
    - the blood.
    - the organs themselves.
  - — Assimilation.
- 3d. Decomposition of organs.
- 4th. Causes that modify nutrition.
- 5th. Of nutrition considered in
  - infancy — Of increase in height.
  - youth — Of increase in thickness.
  - adult age.
  - old age — Decrease.
- 6th. Of natural death.

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GENUS VIII.	1st. Phenomena of animal heat.	
Calorification.	2d. Entrance of caloric by	respiration. digestion. absorption.
	3d. Its latent state in the blood.	
	4th. Its disengagement in the capillary system.	
	5th. Its exit from the body.	
	6th. Of the sympathies of heat, and of sympathetic heat.	

SECOND CLASS.—FUNCTIONS RELATIVE TO THE SPECIES.

A COMPARISON OF THE TWO SEXES. HERMAPHRODISM.

ORDER FIRST.—*Functions peculiar to the male. Phenomena of puberty in man.*

GENUS I.	1st. Secretion in the testicle.	
Production of the semen.	2d. Residence in the vesiculæ.	
	3d. Excretion	Of erection and its phenomena.
	4th. Of the semen.	
	5th. Of eunuchs.	

ORDER SECOND.—*Functions peculiar to the female. Phenomena of puberty in woman.*

GENUS I.	1st. Of its seat.
Menstruation.	2d. Of its periodical return.
	3d. Of its alterations.
	4th. Of its cessation.

GENUS II. *Production of milk.*	1st. Secretion in the breast	Difference of this secretion from others.	
		Relation between the breast and womb.	
	2d. Excretion	spontaneous.	
		by suckling.	
	3d. Of the milk.		
GENUS III. *Of the fluids of women proper for generation.*	What these fluids are.		
	What is their influence.		

ORDER THIRD.—*Functions relative to the union of the sexes, and the product of this union.*

GENUS I. *Generation.*	1st. Sexual intercourse.		
	2d. Conception	Its phenomena	in the womb.
			in the tubes and ovaries.
		Hypotheses.	
GENUS II. *Gestation, relative*	1st. to the mother	General state of her functions.	
		State of the womb.	
	2d. to the fœtus	Of its animal life ; it is almost nothing.	
		Of its organic life	Functions that it wants.
			Activity of assimilation.
		Of monsters.	
GENUS III. *Parturition and subsequent phenomena.*	1st. Causes and mechanism of parturition.		
	2d. Of the lochia.		
	3d. Phenomena of the new born infant	Development of its animal life.	
		Functions added to its organic.	

This is a sketch of the general plan that I have adopted in my lectures. Those who have attended them, will find here some changes in one part, and additions in another. But they can easily arrange under it all the facts that are contained in this work, if they wish to refer them to a physiological classification, instead of distributing them according to the anatomical order in which I present them here.

Though a line of demarcation separates each order of functions, it is not necessary, however, to take, in too exact a sense, the divisions pointed out above. Each order is connected with the others, more or less intimately. For example, in the first class, when one order ceases, another is soon annihilated. It is thus that I have shewn elsewhere that the heart, which is the principal agent of organic life, being interrupted, the brain, which is the central organ of animal life, is immediately stopt for the want of excitement, and the functions over which it presides are destroyed. It is thus also, as I have shown, that the brain, having under its immediate superintendance, respiration, by the means of the diaphragm and intercostals, which receive the cerebral nerves, has the circulation directly under its control, and thus the whole of organic life, which ceases when its action is interrupted. It is on this account that I have considered respiration as the link that connects animal with organic life, and have proved that a fœtus without a brain, or without something to supply its place, cannot live out of the womb of its mother. Every thing is connected, every thing is united in the animal economy. We live without and within in a distinct manner, but one life cannot be preserved as a whole, independent of the other. Thus, though the functions should be studied abstractedly, we should always have in view their connexion, when we consider the whole of them as simultaneously in operation.

It will be seen that in the Descriptive Anatomy, I have adopted a classification analogous to that of physiology. The one differs, however, a little from the other, because the same organs often serve for many functions, and especially because certain functions, such as exhalation, nutrition, calorification, have not, to speak correctly, any distinct and determinate organs.

GENERAL ANATOMY.

SYSTEMS

COMMON TO ALL THE APPARATUS.

GENERAL OBSERVATIONS.

THE organized systems of the living economy may be divided into two great classes. One, generally distributed and every where present, concurs not only in the formation of all the apparatus, but even in that of the other systems, and offers to every organized part a common and uniform base; this includes the cellular, arterial, venous, exhalant, absorbent, and nervous systems. The other, on the contrary, placed in certain determinate apparatus, foreign to the rest of the economy, has a less general and oftentimes an almost insulated existence; this embraces the osseous, cartilaginous, fibrous, muscular, mucous, serous systems, &c. &c.

The first part of this work will be devoted to the examination of the general systems, of the generative systems, if I may so express myself, systems which are not however of such importance that all the organized parts are necessarily provided with these six. In fine, in some there are neither arteries nor veins; in others nerves; in some but little cellular texture; but they concur to form the greatest number, and some are always found where others

are wanting. Thus in the tendons, in the cartilages, &c. which are deprived of blood, there are exhalants, absorbents, &c.

In general, it appears that the exhalant and absorbent systems are the most universally diffused. Nutrition supposes this; in fact this function is the result of a double movement; one of composition, which brings to the organs, the other of decomposition, that carries from them the nutritive matter; now the exhalants are the agents of the first movement, and the absorbents of the second. As every organ is nourished, and as the mechanism of nutrition is uniform, it follows that these two systems belong to all the organs. After them the cellular system is the most generally found. Where there are no blood vessels, it is sometimes met with, and it always exists where these vessels are. Next to this, the arteries and veins are spread to the greatest number of parts. Oftentimes no nerve is discoverable, where they penetrate, as in the aponeuroses, the fibrous membranes, &c. &c. The nervous is of all the generative systems, that which is found by dissection in the smallest number of parts. The serous membranes, the whole fibrous system, the cartilaginous, the fibro-cartilaginous, the osseous, &c. appear to be deprived of it.

Particularly destined to form a part of the structure of other organs, the generative systems perform the same office for one another; thus the cellular texture enters into the composition of the nerves, and the arteries and veins; and the arteries and veins are ramified in the cellular texture, &c. It is a general intermixture of one with the other.

It may be imagined, from what has now been said, that the generative systems, considered under the relation of organs, forming a common and uniform base for all, ought to be sooner developed than others; and this, observation proves. While there is hardly an outline of the others

in the first months of the fœtus, these predominate in a remarkable manner. The nerves, and their centre, which is the brain, the arteries, the veins and their central organ, which is the heart, the cellular texture, the exhalants and the absorbents, exhibit this phenomenon in a striking degree. Mere inspection suffices to prove this in the nervous, arterial, venous and cellular systems; in the other two it is proved by the wonderful activity of absorption and exhalation, at this period of life.

From what has just been said of the general systems of the economy, it is easy to perceive that they perform the most important part of nutrition. They form the nutritive parenchyma of each organ; now I call the nutritive parenchyma, the cellular, vascular and nervous outline of that organ. It is in this outline that the nutritive matter is deposited. This matter being different for each organ, establishes a difference between them. For the bones, it is phosphate of lime and gelatine; it is gelatine alone for the cartilages, tendons, &c.; fibrin for the muscles, albumen for certain other organs; so that if the nutritive parenchyma of a bone was filled with fibrin, it would be a muscle in the form of a bone, and vice versa, a muscle would become a bone with a muscular form, if its parenchyma was filled up with earthy and gelatinous substances. We should know the nature of all the living parts, if their nutritive substances were known to us; but the most of them are unknown, it is chemistry that must enlighten us upon this subject. All the organs resemble each other in their parenchyma, or at least have a great analogy. If it were possible to remove from all, the nutritive matter and leave this parenchyma untouched, we should see only among them, varieties of form, of size, of deposition of cellular layers, of vascular or nervous branches, but not of nature and composition.

In the first period after conception, the mucous mass that represents the fœtus, appears to be only a compound

of the general systems. Each organ has as yet only its nutritive parenchyma, the parenchyma upon which nature has imprinted the form of the organ, that is to be developed there. In proportion as this outline is increased, the nutritive substances penetrate it, and then each organ, which until that time had been like the rest in its nature, and forming with them a homogeneous mass, begins to be distinct, and have a separate existence; each one draws from the blood the substance that is proper for it. This addition gives the attributes of thickness, of density, and of nature; but the increase of parenchyma, the augmentation of its dimensions are always antecedent to this. Whilst all inorganic bodies increase by the addition of particles, there is here at first an expansive force, from which length and breadth arise, afterwards substances are exhaled into the parenchyma, which lengthen and widen it.

By what mechanism is it, that each organ draws the materials of its nutrition from the blood, the common source? This depends entirely upon the organic sensibility peculiar to each, which places it in relation to this or that substance and not to another, and which makes it appropriate it to itself, is penetrated by it, and suffers it to enter its vessels on all sides while it draws back and contracts, to prevent what is foreign to it, from being introduced into its texture.

After this substance has continued for some time to form the organ, it then becomes foreign to it and heterogeneous; by remaining longer it would be injurious; it is absorbed and thrown out by the different emunctories; a new substance of the same kind, which is brought by exhalation, takes its place. Each organ is then constantly in a state of composition and decomposition; but this composition and decomposition vary in their proportion. The predominance of the first over the second, constitutes growth. Their equilibrium establishes the stationary

state of the body, which is the case with the adult. When the activity of the second is greater than that of the first, then decrease and decrepitude follow.

Such is, in short, the manner in which the general theory of nutrition should be considered, a theory which I shall explain at length in my physiology, and upon which I will now offer a few words, to show that it is not a system formed by accident, but that it rests upon the laws of the economy, and upon its organic phenomena. Now I think that this assertion will be demonstrated, if I prove, 1st. the uniformity of the parenchyma of nutrition; 2d. the variety of the nutritive substances; 3d. the faculty which the parenchyma of nutrition has of appropriating to itself, according to the quantity of its organic sensibility, this or that nutritive substance, to the exclusion of others, of afterwards throwing out this substance, and of taking new. These are in fact the fundamental principles of this theory.

I say in the first place, that the parenchyma of nutrition is the same for all the organs, and that it is an assemblage of red vessels, of exhalants, of absorbents, of cellular texture, and of nerves; these are the proofs. 1st. These different organs are met with in all the others, as I have observed before, anatomy shows them every where, between each fibre, each layer, each point, if I may so say; they are truly the common organs. 2d. When we take away from the organs their different nutritive substances, for example, from the bones the phosphate of lime by acid, and the gelatine by boiling, there is a residue which is evidently cellular and vascular. 3d. There is no doubt but that the mechanism of the union of divided parts is the same as that of their natural nutrition. Now in the healing of wounds, the parenchyma of nutrition is first developed, and is every where the same; every where fleshy points appear, which are cellular and vascular, which have the same appearance and same character,

whether they arise from a bone or a cartilage, a muscle, the skin, a ligament, &c. All wounds, in healing, like the organs, resemble each other in their parenchyma; they differ also like the organs, in the nutritive substance that is afterwards deposited in its texture, substances which vary according to the part where the wound happens to be; thus the deposit of the phosphate of lime gives to the callus a different character from that of muscular wounds, which are united by the exhalation of fibrin in the fleshy points that first arise upon the divided surfaces, &c. 4th. The mucous substance which forms the body of the embryo, appears to be nothing but cellular or mucous texture, as Bordeu calls it, which is abundantly supplied with vessels and nerves. In fact, when the organs are developed in this mucous substance, it may be seen in their interstices for a certain length of time, and exhibits there the same appearance as the body of the embryo in the first periods; gradually this substance becomes condensed, is filled with cells, and assumes the form of cellular texture; whence it may be presumed, that in this mucous state of the embryo, there is only the nutritive parenchyma of the organs; and as the parenchyma is the same in all, it is evident that the mass of the embryo must be homogeneous. Nutrition commences, and then each organ appropriates to itself the substance which is proper for it; after this it ceases to be homogeneous. From these considerations, it becomes easy to admit the uniformity of the parenchyma of nutrition, and its cellular, vascular and, in certain cases, nervous texture.

I am aware, that by admitting this common parenchyma of nutrition, it becomes necessary that it should be nourished itself, and consequently that we must go farther back; but in physiology, the art of finding the truth consists, in searching for it in secondary causes; here facts and experiments enlighten our way, beyond that, imagination only is our guide.

After having demonstrated that the organs resemble each other in a common parenchyma of nutrition, it is unnecessary to prove that they differ by the substances that are deposited there. Animal chemistry has within a few years past so much elucidated this point, that it is not worth while to waste time in refuting what has been written upon the identity of the nutritive juice.

In fine, it is easy to conceive, how each parenchyma of nutrition appropriates to itself according to the quantity of organic sensibility it enjoys, the nutritive substances that are proper for it, and which are brought to it by the circulation. It is not a phenomenon peculiar to nutrition; it is observable in all the acts of the organic economy. Thus the secretions take place only in consequence of the determined quantity of this sensibility, which, placing each gland in relation with the fluid that it should separate, makes it receive this fluid, and reject the others; thus the red part of the blood does not ordinarily pass into the exhalants, because the serous part is alone in relation with their organic sensibility; thus the substances that pass the intestines, do not stop in the biliary or pancreatic ducts, although their diameter is sufficient to admit them; thus cantharides are exclusively in relation with the sensibility of the kidneys, mercury with that of the salivary organs, &c. &c.

We see from this, that the mechanism by which the parenchymas of nutrition appropriate to themselves nutritive substances, is not an insulated phenomenon, but a consequence of a general law of organic sensibility. But why has this property as many degrees as there are organs in the economy? Why do these degrees establish relations so different between the organs and the substances that are foreign to them? Let us stop here; let us be contented with proving this fact by a great number of examples, without trying to discover the cause. We could offer nothing but conjectures upon this subject.

These few notions upon the nutritive phenomena, though indirectly connected with the subject of this volume, are not misplaced here; because in these phenomena, the generative systems upon which we are going to treat, perform the greatest part, and because we shall frequently have occasion to refer to them in the examination of the development of the organs, the development that authors have only vaguely examined, upon which the most exact and the most judicious of all physiologists, Haller, has only slightly glanced, but which however ought to receive the particular attention of physicians, of those especially who wish to consider diseases under the essential relation of the influence that age has upon them.

CELLULAR SYSTEM.

THIS system, which many know still, under the name of the cribriform body, the mucous texture, &c. is an assemblage of filaments, and of white soft layers, intermixed and interwoven in different ways, leaving between them spaces communicating together, more or less irregular, and which serve as a reservoir for the fat and serum. Placed around the organs, the different parts of this system act at the same time as a bond to connect, and as an intermediate body to separate them. Carried into the interior of these same organs, they essentially contribute to their structure.

The great extent of this system, which, though every where spread, is every where continuous, the number of organs it surrounds, and the multiplied relations it presents, do not allow me to describe it, as has been done, in one point of view; in order to give a complete view, it is necessary to separate the different points in which it may be examined.

I shall then at first consider abstractedly the general system, as represented by the continuity of all its parts, in order to consider it in relation to the organs that it surrounds, or to whose composition it concurs. I shall examine it afterwards independently of these organs, as it is spread every where in the spaces between them. In fine, its organization, its properties, its relations with other systems, and its development will be the object of my researches.

ARTICLE FIRST.

OF THE CELLULAR SYSTEM CONSIDERED IN RELATION TO THE OTHER ORGANS.

The cellular system, considered in an insulated manner, and in relation to each organ of the animal economy, can be described in two secondary relations. 1st. It forms for each organ a covering, a boundary which is exterior to it. 2d. It enters essentially into the structure of each, and forms one of the essential bases of this structure.

1st. *Of the cellular system upon the exterior of each organ.*

The different conformation of the different organs, establishes two very distinct modifications in the relations of the cellular texture, that is exterior to them. In one case in fact, it is contiguous only to one of their surfaces, in the other it envelopes them entirely. The first arrangement takes place, when these organs have one side free, and the other attached, as for example, the skin. The second, which is the most general, is observed, when an organ is attached every where to those in the vicinity of it. Let us describe separately each of these two arrangements.

Of the cellular system which adheres only to one side of the organs.

There are three membranous organs which are free on one side, and clothed on the other by the cellular texture; these are the skin, and the serous and mucous membranes. We can also consider here, that which covers the exterior of the arteries, the veins, the absorbents and the excretories, which are destitute of it in their interior. As this texture enters also into the structure of these vessels, most authors have examined it, in treating of them. It appears

to me more convenient to present under one point of view all the parts of the cellular system.

Sub-cutaneous cellular texture.

Besides the chorion, into which, as we shall see, a great quantity of cellular texture enters, and which anatomists consider as formed by a particular condensation of this texture, the skin, every where that we examine it, presents a subjacent cellular layer, the quantity and density of which vary in the different parts of the body.

Upon the greatest part of the median line, this texture appears more compact, and more adherent to the skin than in many other places. We may be convinced of this, by dissecting upon the middle of the nose, of the lips, of the sternum, upon the linea alba of the abdomen, upon the range of the vertebral and sacral spinous processes, upon the posterior cervical ligament, &c. From this adhesion arises a sort of division of the two great halves of the sub-cutaneous cellular texture; a division that I have sometimes made very evident in my experiments upon emphysema. The air being driven with moderate force under the integuments of one side of the body, diffuses itself gradually, and is stopped in many instances at the median line, so that one side is puffed up and the other exhibits the ordinary state of the cells. It is oftentimes necessary to increase the force very much, in order to overcome the resistance and render the emphysema general. However, we cannot always produce this phenomenon, and sometimes the air spreads immediately every where; this takes place especially if it is forced in about the neck, for the sub-cutaneous texture is as loose there in front, upon the median line, as it is upon the sides.

It is only from the circumstance, that the sub-cutaneous texture immediately under the median line, is somewhat more compact than elsewhere, that we can say with Bor-

deu, that this texture divides the body perpendicularly into two equal parts. No where, but under the skin, do we see any trace of this separation. Besides, I have demonstrated in one of my works, that the division of the body into two symmetrical parts, is a general attribute of the organs of animal life, an attribute which distinguishes them from those of the internal life, which seem to be characterized by their irregularity; it is under this relation, and not under that of Bordeu, which is contrary to anatomical facts, that the median line should be described.

In the other parts of the body, the sub-cutaneous cellular texture varies considerably. 1st. The density of this texture is remarkable in the hairy scalp, which is with difficulty separated on that account from the aponeuroses and subjacent muscles. Those who have often examined patients who have died of apoplexy, know that sometimes their heads and necks are emphysematous; I have already seen four. Now whilst considerable air is found in the face, little or none is met with under the hairy scalp. 2d. In the face, the sub-cutaneous texture is remarkably loose, it is very abundant there. 3d. Upon the trunk this laxity is also very evident; it accommodates itself to the motions which the great and broad muscles perform there. 4th. Upon the extremities, the sub-cutaneous cellular texture, situated between the aponeuroses and the skin, offers almost every where an equal degree of relaxation. It is only upon the palm of the hand and the sole of the foot that, its texture becoming more compact, the adhesion of the aponeuroses to the skin is more evident, an arrangement that is favourable to the use of these two parts, which are designed to adapt themselves to the forms of external bodies, to grasp and hold them. It is to this compact texture, that must be referred the difficulty that exists of making these parts subject to dropsical effusions. Long after every other part of the sub-cutaneous texture is infil-

trated, this preserves its ordinary state. I have seen two patients affected with elephantiasis, where every part of the skin and subjacent texture of the lower extremities was enormously swelled, except the sole of the foot. The contrast of this part, remaining in its natural state, with the top of the foot, which was raised to an enormous swelling, gave that peculiar appearance that all authors have noticed. At the place of the annular ligaments, the sub-cutaneous cellular texture is very compact, and the adhesion of the skin, is also very evident; hence those contractions that are seen in the limbs of infants at the place of the ligaments, the fat penetrating but very little into the cells, that are very closely drawn together.

The sub-cutaneous cellular texture has several different uses. It furnishes the skin with the great mobility it enjoys, a mobility that is particularly observable in the great motions of the trunk and extremities, in the collisions it experiences with external bodies, in the different tumours that get to a great size, as in sarcocele, which is often covered at the expense of a part of the integuments of the penis, the abdomen and the thigh, which are stretched and have a real locomotion.

It is to this texture also, that the organs subjacent to the skin owe in part the facility with which they move in the great contractions of which they are susceptible. The fat contained in great quantity in its cells, contributes to protect the subjacent parts from the impression of the external air. We know, that in general this fluid is more abundant there in winter than in summer, that it is found in a very considerable proportion under the skin of animals that inhabit cold countries, that in consequence of the emaciation that follows great diseases, the impression of the external air is often very sensible, &c.

The serum appears to be in the sub-cutaneous texture, considerably more than in other parts; it has a greater tendency to accumulate there, no doubt on account of

its laxity. If we compare the quantity of fluid which enters this texture in a dropsical limb, with that which occupies the intervals between the muscles and the interstices of the fibres of the different subjacent organs, we shall see that it exceeds it considerably, and that the size of the limb is in proportion much more increased by the dilatation of the portion of sub-cutaneous cellular texture, than by that of the portions situated deeper. To be convinced of this, place at the side of a healthy, lower limb, stripped of its integuments and subjacent texture, a dropsical limb prepared in the same manner, and consequently having like the other, only its aponeurotic covering, you will see that the difference is not very great.

Sub-mucous cellular texture.

The mucous membranes have the same relations with the cellular texture, that the skin has, of which they are a continuation, and with which, as we shall see, they have a great analogy in their structure. There is then a sub-mucous, as well as a sub-cutaneous texture. But there is between them, this essential difference, that the texture of the first is infinitely more compact and condensed than that of the other, and consequently that the adhesion of the mucous system to the neighbouring parts is much greater, than that of the cutaneous system. It is to this difference that may be referred, 1st. the difficulty of dissecting the mucous membranes and of separating them from the subjacent parts. 2d. The impossibility that I have always found in many successive experiments, of producing an artificial emphysema in the sub-mucous texture, whilst I have done it almost every where else, by blowing in air. 3d. The uniform absence of this fluid in this texture, even when the natural emphysemas are the most generally spread. 4th. The equally uniform absence of serum in the sub-mucous cells, in the most general leucophlegmasia ; a phenomenon essential to the functions of the hollow or-

gans, which would soon be obliterated, if the sub-mucous texture swelled as much in dropsy as the sub-cutaneous.

Is it to the difference of texture of these two portions of the general cellular system, that must be referred the much greater frequency of phlegmonous inflammation in the second than in the first, or is it that this is less exposed to the exciting causes derived from external bodies? Both circumstances may have an effect. I believe much more readily in the first, as the throat, in which is seated, especially around the amygdalæ, the most lax of all the parts of the sub-mucous texture, is the most frequent seat of phlegmonous inflammation.

Besides, it is the firm and compact structure of the sub-mucous texture, which makes it fit to serve as a point of insertion and termination to that number of fleshy fibres that compose the muscular membranes of the stomach, the intestines, the bladder, &c. and thus to fulfil the uses that the tendons have in relation to the muscles of animal life.

Sub-serous cellular texture.

There is under almost all the parts of the serous system, as under the two preceding ones, a cellular layer, which is in general very abundant and very loose, as we may be convinced by examining it around the peritoneum, the pleura, the tunica vaginalis, the pericardium, &c. This quantity of cellular texture is particularly destined to accommodate the different changes these membranes experience, in dilatation, in contraction, and in a species of locomotion, of which they are susceptible under many circumstances. We shall see the peritoneum, for example, belong at one time to the omentum, at another to the stomach, according as this last is in a state of fulness or vacuity; now for these removals, it was necessary that there should be a great degree of laxity in the surrounding texture. It is to this, that we must attribute the ease

with which the sub-serous texture is penetrated with water in dropsies, and with air in emphysema. Next to the subcutaneous texture, no part is more disposed to these infiltrations.

There are, however, some places, where the serous membranes adhere in a very intimate manner to the neighbouring parts. The pericardium in its two layers, the synovial glands with the cartilages and fibrous capsules, the tunica arachnoides with the dura mater, offer examples of this arrangement, which constitutes, when it is with a fibrous membrane that it makes the adhesion, the sero-fibrous membranes.

Cellular texture exterior to the arteries.

There is around each artery an extremely compact, condensed, and resisting layer, which at first sight appears to be a peculiar membrane, but which evidently belongs to the cellular system. It has the greatest analogy with that which is under the mucous membranes. It is never the seat of serous infiltrations. Fat never accumulates there, and it is never attacked with inflammation. It arises in an insensible manner from the neighbouring cellular texture, which is gradually condensed, and intermixed in such a manner, that we can detach it as a whole, so that it will represent a kind of canal corresponding with that of the artery which it surrounds and supports. Are the arterial fibres inserted in this compact texture, as the muscular fibres of the stomach and intestines are, in the sub-mucous texture? I do not think they are; for if it was the case, we could not so easily remove the cellular cylinder that surrounds the arteries; the arterial fibres seem to be whole circles, and consequently not to have, like the muscular, two inserted extremities. However, some of these fibres constantly adhere to the deepest cellular layer, when we remove it; we distinguish them by their direction and yellowish colour.

Cellular texture exterior to the veins.

The veins have an external covering analogous to that of the arteries, but it is in general less thick and compact. It cannot be taken out in an entire cylinder as easily as that of the arteries. Moreover, it does not contain fat, and but little serum, and is not subject to dropsical effusions, but uniformly preserves in all affections its original state. When we raise by layers this texture which is on the outside of the coats of the veins, we easily perceive that it is dryer than in any other part; and I have often been tempted to believe, that it does not, like that of the arteries, the excretories, and mucous surfaces, exhale an albuminous fluid which lubricates the other parts of the cellular system. We shall see that its organization, which is entirely different, forms an exception in this system.

In examining the cellular cylinder of the veins and arteries, especially that of the first, it is essential not to confound it with their filaments, and the numerous nervous branches which come from the ganglions, and form a very thick net-work around them. The cellular texture is whiter, the nerves more greyish; this becomes very apparent after a few days maceration.

I do not speak of the texture external to the absorbents; without doubt they have one like the veins, but so delicate are these vessels, that we can say nothing of them founded upon experiment and dissection.

Cellular texture exterior to the excretory ducts.

All the excretories, the salivary, urinary, spermatic, hepatic, pancreatic, &c. are evidently surrounded with a layer analogous to the preceding, entirely distinct from the neighbouring texture, and which appears to be inserted in it without partaking of its nature; it is a distinct body, as to its thickness, its form, and its texture. The filaments that compose it, not being separated in

their interstices by any fluid, remain in contact with each other; so that the whole really makes a membrane in the form of a canal, which can be easily raised up like that which surrounds the arteries; it is, however, thicker than that of the veins.

Of the cellular system considered in relation to the organs that it surrounds on all sides.

Except the organs of which we have just spoken, all parts of the body are surrounded on every side with a cellular layer more or less abundant, which forms for them, according to the happy expression of Bordeu, a kind of peculiar atmosphere, an atmosphere in the midst of which they are immersed, and which serves to insulate them from the other organs, to interrupt to a certain degree the communications which would unite them in an intimate manner, which would identify, if we may so say, the existence of one with the other, if they were in immediate apposition.

The serous vapour, in which the cellular atmosphere of each organ is constantly immersed, and the fat which floats there in greater or less abundance, powerfully assist in this insulation of vitality; both form for the different organs a line of separation, which, being fluid, enjoys in a much less degree than them the vital forces, which also in this point of view, is not at their level, if I may so express myself, and which is consequently very proper, to interrupt in a certain degree the vital communications that would otherwise exist. The essential difference that there is between the peculiar life of the cellular texture and that of the other organs, renders it also very susceptible of performing alone like a solid, an analogous use independent of the fluids it contains.

It is to this insulation of the vitality of the organs by their surrounding cellular texture, that we can refer in part that of the diseases, which is only an alteration of

this vitality. Every day we see an affected part contiguous to a sound one, without communicating to it its disease. A healthy pleura covering the lungs filled with tubercles, or ulcers, in phthisis; an inflamed peritoneum corresponding with the intestines, the stomach, the liver, the spleen, which remain in their natural state; the mucous membranes affected with catarrhs approaching without danger the numerous parts they cover; the sub-cutaneous organs remaining free from the innumerable eruptions of which the skin is the seat; the tunica arachnoides in a state of suppuration enveloping a healthy brain, and a thousand other similar facts; these are the phenomena that the examination of bodies constantly presents. Shall I speak of the different tumours that are formed in the midst of organs, without their perceiving it, of the numerous excrescences that grow by their side without affecting them? Dissect a muscle under a suppurating cutaneous wound, or even a most obstinate ulcer; you will not often find it different from the rest, the skin only has been affected. No doubt the difference of vitality of two neighbouring organs is an essential cause of the insulation of their diseases; but the cellular atmosphere that protects them is also an important one. When an organ sends elongations into another, it communicates to it much more easily its diseases, than if a thick cellular layer separated them; for example, we know that the affections of the periosteum and the bone are soon identified.

Let us not, however, exaggerate this idea, by describing the cellular atmosphere as an insurmountable barrier to diseases. Facts would often contradict us, by showing diseases passing from an organ to the texture that surrounds it, and from this texture to the neighbouring organs; so that we see it at one time an obstacle, and at another the means of their propagation. The atmosphere that is formed is in different cases susceptible of being

charged with all the emanations that arise from the organ, or to speak in language more strictly medical and physiological, the vital forces of an organ being altered, those of the surrounding texture are often altered by communication, and gradually those of the different neighbouring organs themselves. This kind of influence that the organs have upon each other, should be carefully distinguished from sympathy, in which, a part being diseased, another part becomes affected without the intermediate ones being deranged in their functions. Here there is constantly in the communication of diseases, the same order as in the position of the organs.

A great number of local affections affords us examples of this dependance, in which an organ and its texture being diseased, the neighbouring organs afterwards become so. In phlegmon, a more or less considerable swelling surrounds the red and inflamed place; rheumatism, which affects the white parts of the wrists and fingers, produces a painful swelling around them; a considerable tumefaction in the neighbourhood of the knee is almost always the result of diseases of the joint, which affect only the ligaments, &c. Many tumours have around them a kind of diseased atmosphere, an atmosphere which extends more or less remotely, which always exists in the cellular texture, and which constantly partakes of the nature of the tumour. If it is acute, as in phlegmon, it is a simple swelling which disappears almost entirely at death; as I have often seen in dead bodies an inflamed part that was very large during life, resume by the loss of the vital forces, nearly its ordinary size. Is the tumour chronic? it is an induration more or less evident that affects, oftentimes to a distance, the neighbourhood of the diseased parts, as we see in most cancers.

This atmosphere of disease is developed not only around the affected organ, but embraces also the neighbouring ones. The inflammations of the pleura spread

to the lungs, that of the convex surface of the liver to the diaphragm; pericarditis, by the influence it has on the fleshy fibres of the heart, produces in this organ the irregular motions of an intermittent pulse; peritonitis, which is exclusively confined to the peritoneum, in the beginning, terminates, when it becomes chronic, by affecting the subjacent intestines; it is this which forms chronic enteritis, &c.

It should be remarked, however, that mere contiguity without cellular texture, is often sufficient to communicate disease; for example, a carious tooth affects its neighbour; the inflamed portion of a serous membrane, in contact with healthy ones, soon produces inflammation in them; thus it is, that after inflammation has continued a short time, though the pain has announced only one point to be primarily affected, the whole surface is found attacked.

I am convinced that disease is not the only thing, that the cellular atmosphere of the organs serves to propagate, but it is also the means of communicating medicinal effects. Why is a blister often useless that is applied to a remote part in rheumatism, whilst one placed upon the skin that covers the muscle or the fibrous organ that is the seat of the disease, frequently produces a sudden effect? Why has a cataplasm applied to the scrotum oftentimes an influence upon a diseased testicle, though between the cutaneous organ and this gland there is no relation of vitality? Why do several other medicines applied also to the skin, produce an action upon the subjacent parts? The cellular texture is certainly the means of communication, as in the different applications made to the mucous membranes. A gargle is advantageous in inflammations of the tonsils; an emollient enema diminishes that of the peritoneum, &c.: now these means are not applied directly to the affected organ; their effects are transmitted by the sub-mucous texture. However,

the advantages of these applications have been much exaggerated, both when applied to the cutaneous and mucous surfaces, with a view of acting upon organs of different vitality, and which are subjacent to these surfaces. Practice too often proves that they may be excited, and irritated in a certain manner, without the contiguous organ being affected, because their life and that of the organ has no resemblance or correspondence, the one is indifferent to the affections of the other, though the parts are contiguous. Who does not know, how little effect emollients, discutients, &c. have, upon tumours of the breast, of the glands of the groin, axilla, &c.? and that they are as often cured without our applications as they are with? Formerly, when a tumour appeared projecting under the skin, if it was seated in the abdominal viscera, and consequently separated from the cutaneous organ, by many others of a different and even opposite vitality, they covered it with a poultice. All modern surgeons admit the inutility of applications made in this way, and now confine them to the most subcutaneous organs. Perhaps hereafter we shall be sufficiently acquainted with the degree of vitality of each organ, to know when the cellular texture can be the means of communication of medicinal effects, between two contiguous organs, with different structure and properties, and when it is a barrier which stops the communication of these effects. At present we go almost always groping in the dark.

Frequently a cutaneous application acts by sympathy upon very distant organs, whilst it has no effect upon neighbouring ones, with which it has no relation; for example, a bath will check a spasmodic vomiting, while it will have no sensible effect in diminishing pain which has its immediate seat in the sub-cutaneous organs.

In general, the vital forces of any organized part are particularly altered, and consequently its injuries are

produced in three ways; 1st. by a direct irritation, as when the conjunctiva is inflamed, from fresh air, or that filled with irritating exhalations; 2d. by sympathy, as when one eye being affected, the other becomes so without any apparent cause; 3d. by cellular communication, as when a bone being carious, the skin that covers it becomes discoloured, livid and swelled.

Why is the cellular texture, in some cases, the means that nature uses to defend organs from the influence of that which is diseased, while in others it serves to propagate morbid affections? Let us limit ourselves upon this point to the exposition of facts; the research into the cause, would only be conjecture.

The cellular atmosphere of each organ has relation not only to the immediate phenomena of its vitality, but also to the different movements that the organ executes; as this is more abundant, these movements are more extended. This observation is made, in comparing that which is in considerable quantities around the heart, the great arterial trunks, the eye, the womb, the bladder, the great articulations, as the axilla, the groin, &c. with that which is on the outside of the tendons, the aponeuroses, the bones, &c. and of which there is in general only a very small quantity. The extension and contraction of which its cells are susceptible, make them very proper to accommodate the great movements of the organs, those especially of dilatation and contraction, which moreover are favoured by the fluids that it contains. The organs, upon the external surface of which but little cellular texture is found, and which, however, perform many movements, as the stomach, the intestines, the brain, &c. have, to supply its place, the serous membranes that cover them. These membranes and the cellular texture are in fact the two great means, and the only ones, by which nature has facilitated the movements of these organs.

There are many organized parts with obscure motions, but which are however surrounded with a quantity of cellular texture; the kidnies are a remarkable example of this. The testicle and its membranes are also surrounded with a great quantity of this texture; so is the thyroid gland; the pancreas and salivary glands find it a thick partition which separates them from the neighbouring organs. In general, almost all the immoveable parts, which are not of much importance, and which are not separated from others by serous surfaces, as are almost all the thoracic and abdominal viscera, are every where surrounded by an abundant cellular texture.

II. *Of the internal cellular system of each organ.*

The cellular texture, after having covered the organs, enters every where into their intimate structure; it forms one of their principal elements. In an apparatus, which is an assemblage of many systems, each of these systems is united to the others by it; thus in the stomach, the intestines, the bladder, &c. different layers which belong to it separate the serous, muscular and mucous membranes of these different hollow organs. In the lungs, between the serous surface and the pulmonary parenchyma, between this and the divisions of the bronchia, between them and their mucous surfaces, it offers a variety of elongations more or less compact.

In the organized systems, the cellular texture at first accompanies and surrounds, in their whole course, the vascular and nervous branches which enter into their composition; then it unites together the different homogeneous parts of each of them. Each fasciculus of a muscle, every muscular fibre, every nervous filament, every portion of aponeurosis and ligament, every glandular particle, &c. are surrounded with a sheath, a particular cellular layer, which in relation to its parts, is destined to the same uses that the greater covering of which we have

just spoken, performs for the whole organ. Thus the life of each fibre is insulated by this layer, which, like that of the whole organ, forms around it a kind of atmosphere, destined to defend and protect it, but which can, however, like the general layer, and even more than that, because the parts are nearer to each other, be the means of the communication of diseases from one fibre to another. The motion of each of these fibres is peculiarly favoured by the cellular texture; thus the organs, which, like the muscles, have a very apparent motion in each of their parts taken separately, are capable by means of it of a much greater internal contraction, than those which, like the tendons, the ligaments, and the glands, have no sensible motion but that which is communicated to them.

The internal cellular texture of each organ has but little of the vital character which distinguishes that organ; it preserves almost all its general properties; it is, in the structure of different parts, the medium which unites without resembling them. We see that it is insensible in the nerves, without contractility in the muscles, or powers of secretion in the glands. It is often affected without the participation of the organ. In many organic affections of the liver, we meet with steatomatous tumours, which give this organ a raised and uneven form, and which, occupying only the cellular texture, leave untouched the glandular texture, which secretes as usual the bile, which undergoes no alteration in its course. It is remarkable, that these tumours, oftentimes of enormous size, should exist without injuring the secretion of bile. They may be compared with those not less remarkable in the lungs in phthisis, in which, however, respiration is performed almost the same as in health.

There are many organs, in which the cellular texture is hardly apparent, because their structure is so compact; some authors have even denied the existence of it in them. But in many of these organs, maceration, by fill-

ing in an insensible manner the fibres with water, parts them by degrees, and makes apparent the cellular texture which separates them, as we see especially in the tendons, in the fibrous membranes, &c. Ebullition, which takes from some their nutritive substance, for example gelatine, leaves a membranous residue which is evidently cellular. In all, even the bones and cartilages, the production of fleshy points, or granulations, which, as we shall see, are essentially of a cellular nature, proves the existence of this internal texture, of which they are only the elongations. The same may be said of the bones becoming soft, and fleshy, and of fungous tumours of the other systems, diseases in which this texture becomes very apparent, because the organ loses by them its compact structure, and takes one that is more loose and spongy, and which exposes that which is placed in the interstices of the fibres.

ARTICLE SECOND.

OF THE CELLULAR SYSTEM, CONSIDERED INDEPENDENTLY OF THE ORGANS.

After having considered the cellular system in relation to the organs, let us consider it separate from all the parts that it covers and penetrates, in order to represent it as a body continued on all sides, found every where in the interstices of the organs and being analogous in this point of view to almost all the other primitive systems. Let us trace it in the head, the trunk, and extremities.

I. *Of the cellular system of the head.*

The cranium and face differ extremely as it respects the cellular texture; it is found in very small quantity in the first, and in great abundance in the second.

Cellular texture of the cranium.

The interior of the cranium has but very little cellular texture; it is even apparently destitute of it. If, however, we raise the tunica arachnoides, where the vessels enter and where the nerves go out, we shall find a small quantity, which is remarkable for its delicacy and transparency. The pia mater is principally formed by this texture, and the texture of this membrane appears to be continued with that of the brain; this, however, is extremely hard to be demonstrated; it is not proved by maceration, and it is scarcely seen except in fungous tumours.

The communications of the cellular texture of the interior of the cranium are very numerous.

1st. In front it enters the orbit by the optic foramen and the sphenoidal fissure; hence the redness and heat of the eye in paraphrenitis,* the influence of which is propagated by these communications, as well as by the continuity of membranes. It enters the nostrils by the foramina in the cribriform plate; to this perhaps we may attribute the weight, and pain of the head in coryza.

2d. Below, the numerous foramina of the base of the skull effect communications between the face and the cerebral cellular texture, and between it and the top of the pharynx, the zygomatic furrow, &c. In many cases in which angina is attended with pain, and heaviness in the head, vertigo, &c. I am convinced that it is in a great measure owing to these communications, though oftentimes it may be wholly sympathetic.

3d. Above and behind, the cerebral texture is continued with that of the corresponding parts of the head, by

* The word paraphrenitis is meant probably to designate the inflammation of the meninges of the brain, though this term is not usually employed by English writers; but the word used by the author might be translated inflammation of the diaphragm, which certainly is not his meaning. *Tr.*

the numerous but small openings in the sutures; it accompanies the vessels that go from the dura-mater to the pericranium, and it becomes probably sometimes the means of communication, that is so frequently observed between these two membranes, when one is inflamed; hence the sudden affection that frequently takes place of the dura mater, tunica arachnoides, &c. from a stroke of the sun upon the integuments of the cranium, &c.

The cellular texture, though more abundant on the outside of the cranium, is not found in great quantity there, no doubt because the muscles are so few and thin. Its communications with the face are evident, especially upon the forehead; as a consequence of erisypelas of the cranium, nothing is more common than to see the eye-lids receive the pus that is formed, and which often accumulates in these moveable veils, so as to occasion considerable deposits. It is by these communications also that serum is deposited there, and blood extravasated. Behind and upon the sides, the communications of the cellular texture of the cranium are also very evident.

Cellular texture of the face.

It is very abundant in every part. The orbits are filled with it; the excavation of the cheeks, that is bounded by the buccinator and masseter muscles, the zygomatic and malar bones, contain much of it: all the neighbouring parts of the tongue are furnished with it. The nasal cavities only and their sinuses, which a mucous surface covers, that is almost immediately attached to the bone, have but a small quantity of it.

The facial cellular texture contributes to the beauty and harmony of the countenance, the features of which, examined closely, show that the muscles draw in an unpleasant manner across the skin, when there is no fat, and consequently that there is too great a depression. In

an opposite state, there is a kind of bloating that is disagreeable; a middle state is the most favourable to the beauty of the face. This texture is almost wholly disconnected with expression, which is effected by the muscles. Thus the different passions are delineated with nearly the same features upon a fat and a lean face. Only these features are less marked in the first than the second, because in the last more wrinkles are formed than in the other, by the contraction of the same muscles.

The cellular texture is in greater or less quantity in the face in different people. Every one knows that some are always thin in this part, who are fat in the rest of the body. From the dissection of the bodies of such persons, I have found that it arises from the small quantity of cellular texture it contains in proportion to the other parts. In other individuals, there is an opposite state, a fulness of the face with a lean body, a striking contrast, and which arises without doubt from a cause opposite to the first.

It is to the greater proportion of cellular texture, much more than to the development of the muscles, that must be attributed the evident thickness of certain parts of the face, in different species of the human race, that, for example, of the lips and the alæ of the nose in negroes, &c. From the same cause arises the variety in thickness in the great and small labia pudendi.

The principal communications of the facial cellular texture are made with the neck by the sub-cutaneous portion of this texture, by that which accompanies the vessels, and particularly in the triangular space at the superior part of which is situated the parotid gland. Thus, from deposits made upon the lateral parts of the face, effusions of pus take place that often extend to the neck. In emphysema, the air of which comes from the chest, after the neck is swelled, the air passes to the face principally by the sides. There are still great communi-

cations of cellular texture between the neck and the face, by the spaces between the muscles that are attached to the base of the tongue.

II. *Cellular system of the trunk.*

It varies in its proportions, as we examine the regions of the spine, the neck, the chest, the abdomen, and pelvis.

Vertebral cellular texture.

I so call the cellular texture which is found in the neighbourhood of the spine, and in the vertebral canal.

In the cavity of this canal, there is but very little of it. Between the tunica arachnoides and the medulla oblongata, between the nervous elongations that go from the last, and the sheaths of the arachnoides that accompany them, we see some filaments that follow the course of the vessels, and contribute to the formation of the pia mater. There is none of this texture between the arachnoides and dura mater. Below this, between it and the vertebral canal, in the places where it does not adhere, there is more of it, especially below, where it is very loose, and always covered with a fluid that is often reddish.

On the outside of the spine, we see, behind, many muscles and but little cellular texture in proportion; thus, depositions in this part are much more rare and much less liable to spread than elsewhere, a circumstance which arises also from this, that the muscles being very compact in the vertebral canals, keep in a state of depression the cellular texture that separates them.

This texture is on the contrary very abundant along the whole course of the anterior part of the spine, in the neck, where it accompanies the carotids, in the thorax and abdomen, where it follows the course of the aorta, the great trunks which go from it, the vena cava, azygos, &c. There is no part of the animal economy, more fre-

quently exposed to different collections of pus, than this. Nothing is more common than to see depositions that are formed at the anterior part of the thorax and abdomen, projecting at the groin by a channel which we discover by the examination of bodies. It is principally by these cellular communications, and by those which are beneath the integuments, that the superior parts correspond with the inferior, and vice versa.

Cervical cellular texture.

The neck, which is very muscular, has much cellular texture, besides that which belongs to the vertebral column. It is especially in the lateral parts, where the lymphatic glands are situated, that this texture is remarkable. In the space between the sterno-cleido-mastoideus and trapezius muscles, where the brachial nerves arise, and where the vessels pass that go from the thorax, there is a great quantity of it. It communicates with that of the thorax, by the large opening that is found at the superior part of this cavity; hence it happens, that when the cells of the lungs are ruptured, the escaped air occupies first the chest and then the neck, and hence also the facility with which we produce the same phenomenon by forcing air beneath the pleura of a dead body, &c.

The cellular texture of the neck communicates also with that of the superior extremities above and below the clavicle. Hence why the neck and consequently the chest, are filled with air, water, and other fluids that are forced into the sub-cutaneous and intermuscular texture of these extremities.

Pectoral cellular texture.

In the pectoral cavity, it is upon the median line that the cellular texture is especially found; it is abundant in the space formed by the duplicature of the mediastinum; the neighbourhood of the pericardium is supplied with it,

particularly around the great vessels, which it accompanies a short distance; the rest of the thorax, occupied by the lungs, contains much less of it.

The pectoral texture communicates with the abdominal, 1st. by the different openings of the diaphragm, by that of the aorta, and particularly of the œsophagus; that of the vena cava being too closely united to that vessel, to permit these communications easily; 2d. by the opening of the diaphragmatic fibres, especially by the triangular space, through which those pass that are attached to the ensiform cartilage; hence the passage of the deposits from the thorax to the abdomen. Desault mentions a purulent collection, first formed in the neck, and which by the anterior mediastinum, became prominent just above the abdomen. Hence the facility with which the pleura particularly on the right side receives the influence of diseases of the peritoneum, when this is diseased on the convex surface of the liver which always keeps its place, whilst by the motions of the stomach and the spleen, that which covers those two viscera, which are constantly changing their situation, has a much less decided influence upon the left pleura.

The cellular communications of the chest take place also from the interior to the exterior, by the interstices between the intercostal muscles, but they are not very evident, as these interstices are very small; thus the diseases of the breast have rarely any influence out of this cavity; this happens however when in dropsies and chronic inflammations of the pleura, the pectoral integuments have an adhesion to the diseased side.

The exterior cellular texture of the chest, is very abundant above; it there surrounds the breasts and contributes in part to those rounded forms that delight us in women, and those prominent ones which we admire in a well formed man. We see it in great quantities under

the pectoral muscles; below it diminishes in a very evident manner.

Abdominal cellular texture.

The abdomen contains, in proportion a little more cellular texture than the thorax. In the interior of this cavity, this texture is found collected in the places where the great arteries and veins enter the gastric organs, as in the fissure of the liver, the mesentery, &c. It is not abundant between the peritoneum and the anterior and lateral parietes of the abdomen, but it is so on the posterior part of this membrane, particularly about the kidnies. This interior texture communicates at first with that of the pelvis, all around the peritoneum, then with that of the lower extremities, by different openings, by the inguinal ring and especially by the crural arch. The first of these openings establishes also a cellular correspondence between the abdomen and genital organs, particularly in man. We can easily prove these communications by injecting a fluid into the abdominal cellular texture of a dead body. This fluid goes spontaneously to the inferior extremities, whilst it requires a long continued force to drive it to the superior. All practitioners know, that there is hardly any case of ascites, in which the lower extremities are not swelled, while the superior are unaltered. It is then with the abdominal cellular texture, that that of the inferior extremities has a particular relation, as it is with the pectoral that that of the superior corresponds, as has been observed by Bordeu and Portal. It is to be remarked however, that the first are affected much more easily in the diseases of the abdomen, than the second are in those of the chest.

Cellular texture of the pelvis.

There are but few parts in which the cellular texture is more abundant than in the pelvis. Around the bladder,

rectum and womb there is a great quantity of it, it is found no where more abundantly. This appears to me to be the cause of it; that, as these three organs are subject to great dilatation, and as the osseous parietes of the pelvis cannot yield to these dilatations, like the abdominal parietes, it is necessary that something should so act, that in whatever state the preceding organs may be, the cavity of the pelvis should be always filled. If the motions of the brain alternately increased and diminished the size of this organ, the bony cavity of the cranium would have been lined without doubt with cellular texture.

Besides we know the effect of this large quantity of cellular texture in the pelvis, in deposits which take place in the neighbourhood of the anus, in infiltrations of urine which accompany ruptures of the urethra and bladder. The facility with which pus and urine spread themselves in this part and the mischief they occasion, are well known.

This texture communicates with that of the inferior extremities by the ischiatic notch, by the arch of the pubis, &c. Different authors mention, that effusions of pus and urinous infiltrations extend downwards by these communications. We can fill the pelvis with air, by blowing this fluid into the inferior extremities, especially in their intermuscular texture.

The exterior of the cavity of the pelvis has also much cellular texture, less however behind than upon the sides, but in front around the genital organs of man as well as woman, there are large masses, particularly upon the great labia and the dartos.

III. *Of the cellular system of the extremities.*

In the superior and inferior extremities, the quantity of cellular texture decreases from the superior to the inferior part. Around the two superior articulations, it is very abundant. The hollow of the axilla, in which the

head of the humerus is situated, and which is spacious, is almost entirely filled with it. The groin has also considerable, though less than the axilla. The arm and the thigh have between their muscles large interstices that are cellular. At the elbow there is a smaller proportion than at the ham, whose deep cavity has a considerable quantity; an arrangement that is consequently the reverse of that of the axilla compared with that of the groin.

In the fore arm and leg, the muscles approach each other in a sensible manner; their cellular layers are much more compact, the whole cellular system is less abundant.

Towards the inferior part of these two portions of the limbs, where almost every thing on the hand and foot are tendinous and fibrous, the cellular texture diminishes still more, and becomes in proportion to the motions, hardly sensible. However, the foot, especially on the sole, contains much more than the palm of the hand, where we see but little.

This successive decrease of the cellular texture of the limbs is adapted to the uses of their different parts. In fact the extent of motion that exists above, requires in the muscles a laxity which they borrow from the quantity of cellular texture that surrounds them. Below, the multiplicity and at the same time the limited extent of the motions of the hand and the foot, of the hand especially which is destined to adapt itself to the form of external bodies, require in the organs of these two parts a close juxta-position, for which they are indebted to the small quantity of cellular texture that exists there.

ARTICLE THIRD.

OF THE FORMS OF THE CELLULAR SYSTEM, AND THE FLUIDS IT CONTAINS.

I. *Of the cells.*

The general conformation of the cellular texture is not the same every where. The interstices or cells between the different layers, are more or less wide; their size is remarkable upon the eyelids and the scrotum, and in general where there is no fat, or where it is in small quantity. Moreover the capacity of the cells is extremely variable; nothing definite can be determined upon this point, as they are capable of contraction and expansion. When fat and serum fill them, they are double, triple or even quadruple what they are when they are empty. It is the variation in the size of the cells of the system of which we speak, which constitutes all the difference of the general size of the body in corpulency or emaciation; in each state the size of every nervous, tendinous fibre, &c. remains nearly the same, and the cellular system only varies. There is the same variety in leucophlegmasia compared with the ordinary state of the body.

The figure of the cells is so variable, that we cannot describe them in a general manner. Round, quadrangular, hexagonal, oval, are found mixed together. The best way to see these, is to freeze an infiltrated limb; numerous little icicles are then formed, and show by their form, that of the cells which they filled. Artificial emphysema is also a good way; I have often determined by it in our slaughter houses where they blow meats, the forms of the cells. The injection of melted gelatine may also be employed; but the results are less certain, because

in going from one cell to another, it breaks the texture; and moreover after it is hardened, it is difficult to separate each portion contained in each cell.

All the cells communicate; so that the cellular texture is really permeable throughout the whole extent of the body, from the feet to the head. This permeability is proved, 1st. by emphysema spontaneously produced; 2d. by that which is artificially produced in a living animal, by blowing air under any portion of the cutaneous organ, an operation which affects neither the life or health of the animal, though oftentimes the whole of the body is bloated. We know that some beggars make use of these means without danger, for the purpose of exciting compassion. 3d. If one or two punctures are made in a dropsical limb, it is sometimes wholly emptied in this way. 4th. Oftentimes this happens from ruptures taking place spontaneously in limbs of this kind. 5th. Pressure made upon them, makes the fluid ascend or descend, according to the part upon which it is made. 6th. A rupture of the bladder or the urethra produces an urinous infiltration, which sometimes extends even to the sides of the chest. 7th. The injection of any fluid into the cellular texture of a dead body, produces an artificial leucophlegmasia.

The permeability of the cellular texture has been much exaggerated, or rather it has been presented under a point of view different from that in which it is shown by nature. It is thus that many physicians, thinking that it could be pervaded indifferently by all the fluids of the animal economy, have believed that these fluids formed there, currents in different directions more or less irregular. Thus the sweat has been considered as the transmission by the skin of the albuminous fluid of the cellular texture, which, according to some moderns, is drawn out with the caloric that is constantly disengaged. They have thought, also, that the permeability of this texture would explain the rapid passage of drinks to the bladder. They have

explained by it too, the promptness with which sweat is produced by warm liquors, &c.

All these theories, that examination never proves, are repugnant to the known laws of our economy, laws which show us the fluids constantly circulating in the vessels, in consequence of the vital forces, of organic sensibility and contractility which they possess, and not as being extravasated to move irregularly in the cellular texture. Moreover, I have never found any portion of drink in the cellular texture of animals immediately after they have taken it. I have tried many of these experiments upon dogs, after having deprived them for some time of drink, that they might drink the more. The cellular texture in the neighbourhood of the stomach and intestines, that especially which, placed behind the mesentery, communicates with the pelvis where the bladder is situated, having been attentively examined, did not appear to me to contain any fluid; it was analogous to that of the other parts of the body. Besides, as we shall see hereafter, these phenomena can be explained in a very natural manner.

The cellular texture is permeable, then, only to fat and lymph; and yet it appears that but little use is made in an ordinary state of this permeability by these two fluids, which remain in their cells, until absorption takes them up. We do not see them pass from one to another; they are stagnant, if we may so say. It is only in serous infiltrations, in effusions of pus, in one word, in a morbid state, that the cellular permeability becomes apparent. We can only consider, then, the cellular texture as the reservoir, in which are formed the serum and the fat. After death the cellular texture is every where penetrated by fluids, which pass not only across the communicating openings of its cells, but also through the pores which it has, like all the solids; hence the infiltration of the integuments of the back, in dead bodies that have

been laid upon it for a length of time; hence also the passage of the bile through the texture, which separates the gall bladder from the duodenum, and by which means this intestine is discoloured, &c. &c. But these phenomena have nothing in common with those that take place in the living body.

II. *Of the serum of the cellular membrane.*

The first of the two cellular fluids appears to be the same as that which is elsewhere furnished by the exhalants and taken up by the absorbents. The first deposit it in the organs, the second carry it from them. Thus when we expose to the air condensed by cold any part of the cellular texture of an animal recently killed and still preserving its heat, we see a vapour arise which results from the solution of the serum in this air, a vapour perfectly analogous to a cloud that transpiration and respiration produce in winter, or even to that which arises from any aqueous fluid, exposed hot, with a large surface to the action of fresh air. When the atmosphere is warm the solution takes place in the same way, but as the vapour is not condensed, there is no apparent cloud.

The cellular serum varies in quantity in the different regions. Where there is no fat, as in the scrotum, the eye-lids, the prepuce, &c. it appears to be a little more abundant than elsewhere. We see also that these parts are much more disposed to different infiltrations. In this respect, the scrotum holds the first rank; then come the eye-lids, afterwards the prepuce, &c. Observe upon this subject, that the cellular texture exterior to the mucous surfaces, the arteries, the veins, and excretories, a texture which by the absence of fat resembles the ordinary, differs from it, however, in this, that serum is never effused in it.

We cannot judge of the quantity of cellular serum by observations made upon the dead body, in which the

laxity of the parts permits a transudation of the fluids from all the vessels that pass through the cellular texture, and which then enter the cells. To estimate accurately the cellular moisture, I made an animal first emphysematous below the skin; I made a large incision into this; little blood only escaped, because the swelling separated the vessels from the course of the knife. By these means, the cellular texture being laid open, I have often been convinced that there was much less serum in this texture than we commonly suppose. I have not observed, that during digestion, after sleep, and whilst much sweat is exhaled by the cutaneous organ, three circumstances under which I have repeated these experiments, that the cellular serum is increased or diminished in a sensible manner. This fact coincides with what I have stated in my Treatise on the Membranes, upon the fluid that lubricates the serous surfaces, and the proportion of which is almost always nearly equal.

We know that in leucophlegmasia, the quantity of cellular serum is much increased; that it disappears in inflammation, &c.

The nature of this fluid appears to be essentially albuminous; experiments made upon that of leucophlegmasia show that there is albumen in it; but has not disease then altered its nature? To be satisfied in this respect, I first made a dead animal emphysematous, for the purpose of distending the cells, and to make the alkohol, which I afterwards injected by a syringe, enter them more easily. Some minutes after, the skin having been removed, the subjacent texture presented here and there different whitish flakes. By immersing in diluted nitric acid the cellular portion of the scrotum of a sound body that is dead, or which is better, a portion taken directly from a living animal, we can observe the same thing. It appears, then, that in health as well as disease, the albumen is one of the essential principles of the fluid

of the cellular texture. I have taken much of this texture from the scrotum of many bodies, so as to have it separate from the fat, and I have made it boil in about the same time as nearly the same quantity of tendinous substance; at the moment of ebullition, much whitish froth rises upon the water, but little appears in that which contains the tendons.

Is the nature of the cellular fluid the same as that of the lymph that circulates in the absorbents? It cannot be doubted but that these vessels take off this fluid in the cells; it is possible that it is mixed with other substances, those especially that come from nutrition, which alter its nature. Chemical analysis is defective upon this point.

III. *Of the cellular fat.*

The fat is the second of the fluids for which the cellular texture serves as a reservoir.

Natural proportions of the fat.

Very abundant under the skin, around the serous surfaces, the organs of great motions, &c.; it is wanting, as we have said, upon the penis, the prepuce, the scrotum, &c. under the mucous surfaces, around the arteries, the veins, &c. Examined in the interior of the organized systems, the fat varies in quantity. There is none between the interstices of the arterial and venous coats. The lymphatic glands do not appear to contain any. The brain and spinal marrow are destitute of it. It is always found in the intervals of the nervous fibres; it is not often very evident; but in dissecting them, an unctuous substance escapes, which is constant, and which it undoubtedly furnishes. For the most part, it is in considerable quantity in the muscles, especially those of animal life; very little of it is seen in those of organic. In the bones, where there is none, its place is supplied by medullary substance; the cartilages, the fibrous bodies,

the fibro-cartilages, are almost entirely destitute of it. The glandular system sometimes has it, as we see it in the parotids, around the pelvis of the kidnies; in other places, as in the liver, the prostate, &c. there is no trace of it. The serous and cutaneous systems are never fatty, although much fat surrounds them. It is the same of the mucous; the epidermis and the hair never have any of this fluid.

From this we perceive that the interior of the organized systems contain in general but very little fat. The different apparatus have but a small proportion between their various parts. It is thus that between the coats of the stomach, the intestines, the bladder, &c. between the periosteum and the bone, between that and the cartilage, between the muscle and the tendon, &c. this fluid is almost always wanting.

It follows from this that it is principally in the interstices, which the different apparatus leave between them, that fat accumulates in cellular reservoirs. Now by examining the different regions, in this point of view, we see, 1st. that upon the head, the cranium and face have an inverse arrangement; that it is very abundant in the second, and wanting in the first, especially in the interior; 2d. that the neck contains a considerable proportion; 3d. that in the thorax we see very little around the lungs, but much about the heart; that upon the exterior of this cavity, the superior part has a considerable quantity around the breasts; 4th. that in the abdomen, it particularly abounds in the posterior part in the neighbourhood of the kidnies, the mesentery, and omentum; 5th. that in the pelvis, there is much of it near the bladder and rectum; 6th. that upon the extremities it is found, like the cellular texture, more abundant above and in the vicinity of the great articulations, &c.

We observe in infancy, that the quantity of fat is in proportion much more considerable under the skin, than

any where else, especially that in the abdomen the cellular viscera, the omentum in particular contains but very little at this age. I have established this fact in a great many instances. There are only some flakes of fat around the kidney, frequently these are scarcely visible. All the rest of the abdominal cavity is destitute of it. The pectoral cavity contains scarcely any more, and always much less in proportion than in after life. I have observed also that the intermuscular texture is almost every where deprived of it. We may say, then, that all this fluid is concentrated under the skin, at least while the fœtus is in good health. Does this superabundance of sub-cutaneous fat perform any important office? has it any connexion with the great size of the liver at that period? I know not: it is a phenomenon that should fix the attention of physiologists, especially when it is compared with the absence of fat in almost all the parts where it is afterwards accumulated.

Towards adult age, the abdominal fat is in much greater proportion than the sub-cutaneous. The exterior swelling is as rare towards the fortieth year, as it is common about the fourth and fifth, a period at which all the muscular forms are concealed by the superabundance of fat, and the body is remarkably rounded. Is there any connexion between the large quantity of abdominal fat at the adult period, and the frequency of diseases of which this region is then the seat?

However, the proportions of fat for the different ages are not always the same; there are some exceptions.

In old age almost all the fat is dissolved and disappears; the body is wrinkled, hardened, and becomes thin.

Unnatural proportions of fat.

Oftentimes the fat accumulates in very great quantity in the cellular texture. I will not cite examples of those enormous collections, of which different authors have

given a number of cases; this would be superfluous. I shall only observe, that this state of great corpulency, far from being a sign of health, indicates almost always a weakness of the absorbents which are destined to take off the fat, and has, in this point of view, much greater analogy to serous infiltrations than we commonly think. Different facts establish this assertion. 1st. Every kind of unnatural corpulency is accompanied with a debility of the muscular power, with a state of lassitude and languor of the individual who is the subject of it. 2d. In a man in whom strength and activity predominate, we do not see this fatty enlargement that hides the prominences of the muscles; these are distinctly marked. It is necessary to distinguish carefully the size of the body which arises from cellular fat, from that which is the consequence of the proper development and nutrition of the organs. 3d. Oftentimes the causes which evidently weaken the powers of life, produce a considerable quantity of fat; such as inactivity, rest, great and long continued hemorrhage, convalescence from certain acute diseases, in which the powers still languish, though fat abounds. 4th. A fatty state of the muscles is a state of evident weakness in them. 5th. I have been sometimes convinced, in examining atrophous limbs, that the small size which they retain is owing in part to the fat, which is in proportion almost equal to that of sound limbs, whilst all the other parts, the muscles in particular, are contracted and hardened. 6th. Castration, which takes from the vital powers a part of their activity, from nutrition a part of its energy, is very often marked by excessive corpulency. 7th. On the other hand, as a certain degree of development of the vital powers is necessary for generation, individuals who are too fat, in whom this degree is wanting, are in general not fitted for this function. In woman, this fact is remarkable, it is not less so in man. In other animals we make the same observation. As fowls are

fattened for the table, they cease to lay eggs. Most domestic animals are governed by the same law. We should say that there is a constant relation between the secretion of semen and the exhalation of fat, and that these two fluids are in an inverse ratio to each other.

We may conclude from these facts, that if the moderate exhalation of fat indicates strength, its superabundance is almost always a sign of weakness, and that there is in this point of view a kind of connexion between fatty and serous infiltrations, as I have mentioned before. It should be observed, however, that leucophlegmasia almost always arises from an organic disease of some of the viscera, particularly the heart, the lungs, the liver, the womb, and the spleen; hence it is usually incurable, and death is the consequence of the organic disease. On the other hand, an organic disease rarely accompanies corpulency, which does not prevent a long life. If leucophlegmasia arose only from cellular weakness, I am persuaded that it would not disturb the regularity of the functions.

Great fatty collections are oftentimes an effect almost instantaneous of certain circumstances, for example, of atmospheric influence. It is thus that in twenty-four hours, a fog fattens thrushes, ortolans, red-throats, &c. so that they are unable to escape the sportsman. This phenomenon, which is very frequent in autumn, is never so striking in the human species.

The diminution of the fat is as frequent as its increase, and it may be said that there are more cases of extreme emaciation than of remarkable corpulency. The causes which diminish this fluid are these: 1st. long abstinence; the necessary fasting and sleep of dormant animals, furnish us with an example of this; so that in this point of view, fat is the nourishment which is reserved for the time when the ordinary kind is taken away; 2d. every organic disease, continued for a long time, as phthisis, cancer

of the pylorus and womb, disorders of the liver, of the heart, &c.; those who are in the habit of examining bodies can judge by the external appearance, without knowing the previous disease, whether the organization of an essential part is changed. In general, in organic affections, there is not only emaciation, but also an alteration in the nutrition of the organs; they are more slender than usual. On the other hand, after an acute fever that has lasted only a few days, emaciation only is observed; nutrition, a function that is deranged as it is exercised, that is to say, slowly, is not yet sensibly affected. There is in this respect a great difference between two bodies equally emaciated; it is sufficient, in most cases, to dissect a limb of each, without seeing the internal viscera, to determine if death has been the gradual effect of an organic disease, or the sudden result of a bilious or putrid fever, &c. To the causes already pointed out, we must add, 3d. every considerable purulent collection, especially if it depends upon a chronic affection; 4th. leucophlegmasia, though we must not believe that fat and serum mutually exclude each other, since we often observe much subcutaneous fat in dropsical subjects; 5th. all melancholy affections of the mind which have an influence especially upon the internal life, and which affect the organs of it more particularly than those of external life; 6th. long-continued efforts of the mind, which in a particular manner affect the brain, consequently the first effect is upon animal life, though I have observed that an injury of the functions of this life has less effect upon corpulency than that of the functions of the other; 7th. all evacuations unnaturally increased, as those of the bile, the urine, the saliva, &c.; too frequent emissions of semen, &c. catarrhs, those especially that are seated on large surfaces, as the pulmonary, intestinal, &c.; 8th. long heat of summer, compared with the cold of winter, which is in general favourable to an increase of fat; 9th. running, hard

labour, fatigue of every kind; 10th. long diseases, those especially where it is necessary to use only weak aliments, and not being able to continue even these for a long time; 11th. long-continued watchfulness; long sleep producing a contrary effect, that of increasing the fat; 12th. the immoderate use of spirituous liquors, &c. &c.; 13th. the use of acrid and spicy aliments, of those which have opposite properties to the farinaceous, &c. &c.

I do not cite a great number of the causes of emaciation; after these it will be easily perceived what are omitted. I would only remark, that almost all may be referred to two principles, viz. 1st. a general weakness of the powers, a weakness that acts upon the cellular system, as upon all the others, and produces there this phenomenon; 2d. a partial weakness of this system, a weakness arising from the affection of some other organ, whose action seems to increase at the expense of that of the cellular texture.

Different states of the fat.

The fat is almost always solid and coagulated in dead bodies, but in the living it approaches nearer a liquid state, at least in certain parts, as around the heart, the great vessels, &c. Under the skin it has uniformly more consistence. In many experiments, where I have had occasion to open living animals with red and warm blood, I have never found it exactly flowing as it is when it is melted, though many authors have pretended that it is so, an opinion founded upon the belief that the vital heat would keep it melted. Undoubtedly a degree of heat equal to that of our bodies, acting upon fat out of the body, would make it much more fluid than it is in the living subject. Besides, we know that the temperature is nearly uniform, and that the degrees of the consistence of fat vary remarkably. There is a great difference

between that of the omentum, which is among the most fluid of the economy, and that of the neighbourhood of the kidnies, the skin, which is much firmer. Many animals with red and cold blood have liquid fat.

In general, it appears that the nature and state of this fluid are not the same in all the regions; that the fat of the abdomen, thorax and brain differs from each other, though there is no precise rule concerning these differences.

In young animals the fat is white and very consistent after death. It is this consistence that gives to the external covering of the human fœtus, a remarkable firmness and condensation, whilst in the adult the skin of a dead body is flaccid and loose, yields to the least communicated motion on account of the state of the sub-cutaneous fat. This fat in the fœtus is formed into little globules more or less rounded, which give the whole a granulated appearance. Oftentimes it even forms considerable masses; for example there is almost always at this period, between the buccinator, the masseter and the integuments, a ball of fat, which is separate from the surrounding fat, and can be taken out whole. It contributes very much to the remarkable prominence the cheeks have at this period of life.

Fat becomes yellow as we advance in years, and acquires a peculiar smell and taste. In comparing that of veal with that of beef, we readily perceive the difference on our tables. In the dissecting room, this difference is not less remarkable between a subject of ten years and one of sixty.

Instead of fat, we often find around the heart of dropsical and phthisical patients, and of all those who have died of a disease, in which there has been a constant and protracted weakness, a yellowish substance, transparent and fluid, having a gelatinous appearance, and which however, approaches near the character of albumen.

This substance also occupies in similar cases other parts; but it is less frequent there. It appears to be gelatinous rather than oily.

Exhalation of fat.

Different hypotheses have been proposed concerning the manner in which fat is separated from the blood. Malphigi spoke of glands and excretory ducts, which no anatomist since his time has seen and which no one believes in at present. Haller supposed that the fat was completely formed in the arterial system, that it circulated with the blood and floated on its surface on account of its specific levity. This circulating fat then, according to him, escaped through the pores of the arteries, and oozed from all parts into the neighbouring cellular texture. This opinion supposes two things; 1st. the existence of fat ready formed in the arterial system, an existence that is proved by no positive fact, of which I never could convince myself by the examination of red blood as it comes out of the vessels, for if it did exist there would be numerous little drops floating on its surface at the moment it was drawn. In my experiments upon the colouring of the blood, I have frequently established this; I have observed it also in examining the blood of maniacs upon whom arteriotomy has been performed at the Hôtel Dieu. 2d. The opinion of Haller is founded upon a transudation truly mechanical, a transudation that easily takes place in dead bodies, but never in living. In fact, if we lay bare an artery of a living animal, separate it entirely from every thing else, and examine it ever so long, we shall discover no oozing of fat through its coats, though the blood circulates in it as usual. There is an infinity of arteries, spread in the cellular texture, through which fat never transudes, as we see in the scrotum, the eyelids, &c.; now in these places the arteries are organized as elsewhere, and they ought therefore to have the fat ready

formed in the blood that they circulate; then, according to Haller, fat would be deposited there. Besides, we shall see under the article upon exhalations, that this transudation through the pores of the arteries, whatever fluid is supposed to be transuded is evidently repugnant to the laws of the animal economy. I refer then to this article, to establish the fallacy of Haller's opinion; under that article we shall see also, that the fat is separated by an exhalation analogous to that of all other exhaled fluids, that is to say, by the vessels of a particular order, which are intermediate between the extremities of the arteries and the cellular texture. Some authors have thought that they saw the vessels that carry the fat, and have designated them under the name of adipose; but it appears, that like the other exhalants, they are invisible and can only be proved by a train of reasoning, which however, satisfactorily establishes their existence. We can apply to the exhalants of fat, what will be said upon the exhalant system in general.

I will not treat of the chemical nature of fat, of the acid it contains, of the particular alterations it undergoes under different circumstances, that for example, that it experiences when animal substances that contain it, such as the skin, the muscles, &c. are for a long time macerated in water. This would lead me into details foreign to this work. Besides, I could add nothing to what modern chemists have said upon this subject.

I will terminate this article with an important remark; it is this, that in those parts which nature has deprived of fat, it would have injured their functions. The penis increased in size by it, would not have had a proper relation to the vagina. The eyelids loaded with fat could scarcely be raised. Accumulated in the sub-mucous texture, it would have contracted the cavity of the organs which the mucous surfaces line. Spread in that which surrounds the arteries, the veins and the

excretories, it would have obstructed the caliber of these vessels; and here observe, that its uniform absence in the sub-arterial texture is a proof against the opinion of Haller upon its transudation. Accumulated in the cerebral cavity, it would have compressed the brain on account of the resistance of the bony parietes of the cranium, &c. which do not yield like those of the abdomen, when the gastric viscera are loaded with fat. In the thorax, the diaphragm can descend, and the lungs can without danger occupy less space when there is considerable fat exhaled in the mediastinum. This remark, applicable also to the serum, explains an important phenomenon in diseases, viz. that a very small quantity of fluid poured out upon the tunica arachnoides can disturb the functions of the brain, whilst a great effusion is unattended with danger in the abdomen or the thorax.

ARTICLE FOURTH.

ORGANIZATION OF THE CELLULAR SYSTEM.

The cellular system, like almost all the others, is composed of a peculiar texture and of common parts.

I. *Of the texture peculiar to the organization of the cellular system.*

Much has been written upon the nature of this texture; Bordeu has given some vague ideas upon it, but no experiments. Fontana has made researches which lead but to few results, upon its intimate structure and upon the tortuous cylinders of which, according to him, it is an assemblage. Let us throw aside all hypotheses that examination does not support; let us follow nature in the phenomena of structure that she shows us, and not in those

she wishes to conceal. In thus considering the cellular texture, we see that it is very different from a species of glue, with which some have wished to compare it. It is an assemblage of many whitish filaments, crossing very often certain kinds of delicate layers, which form cells with these filaments. To see this organization well, a piece of the cellular portion of the scrotum should be taken, which has no fat, and whose texture is consequently not concealed by this fluid; this portion being stretched into a kind of membrane, is seen very distinctly. Then there may be plainly distinguished, 1st. a transparent net-work, arranged in layers, which makes the foundation, if we may so say, and the tenuity of which is such. that it has been aptly compared by a physiologist, to the soap bubbles that are thrown into the air with a pipe. It is impossible to distinguish, by the naked eye, any fibre in the texture of these layers; every thing is there uniform. 2d. They are very evidently crossed by numerous filaments, which running in all directions, are interwoven in every way, all of which touch, when the cellular texture is pressed together, but when stretched out, there can be seen between them the layers of which I have just spoken. The more it is extended, the larger consequently the membrane becomes, the interstices between the filaments are greater, and the intermediate layers are also more apparent.

What is the nature of these filaments? I presume that some are absorbents, others exhalants, and that many are formed in the places where the layers unite together for the formation of the cells. As the thickness arising from this union is greater, they are distinguished by more evident lines upon the cellular texture stretched into a membrane. What induces me to believe this, is, that when, instead of examining the cellular texture upon a portion taken from the scrotum, and stretched as I have described, it is observed in an artificial emphysema, as

in that of the slaughter-houses for example, then there is seen upon the covering of each cell, only the non-filamentous layers of which I have spoken, without any of those filaments that were seen crossing it in the other method.

These layers have not the same thickness in all cases; quite dense when the cellular texture is contracted, they become, when it is distended with air or any other means, so fine and attenuated, that the mind cannot conceive that there is any thing organized in them. Their organization is real, however, though some have doubted it. What in fact is a texture that is nourished, inflames and suppurates, which is the seat of very distinct vital functions, and which evidently lives, if it is not an organic texture? All these vague ideas of concrete juices, of inorganic glue, of hardened juice, that have been applied to the cellular texture, have no solid foundation, and rest neither upon experiment or observation, and ought to be banished from a science in which imagination is nothing, and facts every thing.

The cellular texture has essential differences of organization; everywhere where fat or serum is accumulated, there are real cells which have little sacs communicating with each other, which form reservoirs, the sides of which are composed of the transparent and non-filamentous layers of which we have spoken; it is in these sacs that the serous and fatty depositions take place. On the other hand, in the sub-mucous texture, in that which forms the external membrane of arteries, veins, and excretories, there are none of these sacs, no cells, properly speaking, and no layers to form them. When we carefully raise this texture, and lift it from the surface upon which it is applied, and draw it a little so as to show its structure, we shall see very distinctly numerous filaments interwoven every way, forming a true net-work, meshes, if I may so express myself, but not sacs and cavities.

The air distends this net-work when it is driven forcibly into the neighbouring texture; but as soon as an opening is made near it, it escapes, and the texture sinks down; when accumulated in the ordinary texture, the sub-cutaneous, intermuscular, &c. it remains in the cells, notwithstanding they have been in part opened, without doubt because the communicating openings are very small. This fact is evident in markets, where we see the cellular texture blown up, around the meats that are stripped of their skin.

It appears that the filaments that are interwoven in every way, and which form about the vessels and under the mucous surfaces, a cellular net-work, are really of the same nature as those spread in different directions in the membranous layers which make the cells, only they are nearer together, and are by themselves.

After what I have said, it is evident that there are two things in the common cellular texture; 1st. a number of fine, transparent layers, found everywhere where the texture is loose, capable of yielding suddenly to different distensions, and of retaining the fluids its cells contain, &c.: 2d. filaments intermixed with these layers wherever they are, and existing alone in certain places. These layers and cellular filaments have a remarkable tendency to absorb atmospheric moisture. We observe it in dissecting rooms, where a subject dry and easy to dissect in the morning, is often much infiltrated by evening, if the weather has been damp; now this infiltration takes place in the cellular system, which is a real hygrometer.

Composition of the cellular texture.

Chemists have placed this texture in the general class of white organs, among those which furnish a great quantity of gelatine. It has this in fact, and we obtain by a solution of tannin a remarkable precipitate from the water in which this texture has been boiled, without any

foreign organs except the vessels that run through it, as, for example, that of the scrotum. I have made this experiment. But, however, different re-agents act very differently upon this texture, as they do upon the fibrous, cutaneous, cartilaginous textures, &c.

Exposed to the action of the air, the cellular texture dries quickly, but without taking the yellowish colour of the fibrous texture; it remains white. When it is dried in considerable layers, its cells adhere together, and these layers being stretched a little to facilitate the drying, represent a true serous membrane, so that it would be impossible to distinguish it from one dried in the same way. In this state the cellular texture is pliable; it can be bent with great ease in every direction; it has not the stiffness of dried fibrous texture; when immersed again in water, it takes but imperfectly its former appearance; its cells are separated with difficulty.

Exposed to putrefaction with other animal substances, it yields to it less readily than many of them, for example, than the glandular and muscular organs; filled with the putrefactive juices it does not become pulpy until some time after these parts. This fact is particularly remarkable in the sub-mucous texture, in that which surrounds the vessels; the filaments that compose it, resist much longer than the other parts of the cellular system, the putrefactive process.

The same may be said of maceration as of the preceding phenomena. In looking at a tendon and a portion of cellular texture, who would say that the action of water would soften the first quicker than the second? the one being soft and almost fluid, and the other compact. After remaining in water three months, of the temperature of a cellar, the cellular texture of the arteries did not appear to me to have undergone any alteration. The sub-cutaneous, the sub-serous, the intermuscular textures, &c. are changed sooner, but not so soon as that

of some other organs. I have kept for six months, in a glass vessel, some nerves, which as we shall see, are not altered in water; the texture which separated the fibres of these, was as firm and distinct as at first. This resistance to the action of water is less, when the cellular texture is macerated with organs that soon yield and become pulpy, than when it is exposed alone. This resistance is the more remarkable, as this texture, being very fine, is accessible at many points to the contact of the fluid. If the texture of tendons, of cartilages, of aponeuroses, of the skin, &c. was arranged in layers as fine and as much separated, I am satisfied that three or four days of maceration would be sufficient to reduce them to a mere pulp.

As much may be said of ebullition; a few minutes would be sufficient to dissipate and melt into gelatine most of the white textures, if they were arranged in layers as fine as the cellular system; this, however, resists a long time; different layers are still seen between the fibres of the boiled muscles. The fat which remains in parcels among the fleshy fibres, after the boiling, would have been melted, if it had not been contained in cells which continue untouched; we can, moreover, be easily convinced of the existence of these layers in the parcels of fat. It is especially upon the texture exterior to the arteries, the excretories, &c. that the action of boiling water is longest in producing an effect.

The cellular texture that is boiled exhibits phenomena analogous to other organs treated in the same way. 1st. At the instant of boiling, when an albuminous froth rises upon the water that contains it, it remains soft, and about the same it was at first. 2d. When this froth is formed, it becomes hard, is crisped and contracted in size. The hardening increases until it boils, which takes place almost immediately. In this state the texture is firmer; it has become elastic; if drawn in an opposite direction, it

suddenly returns, which it would not do before. 3d. Ebullition being continued, it gradually softens and loses the hardness it had acquired; then it can hardly be extended at all; it may be much elongated without breaking, in a natural state, the rupture of it is now the effect of the least effort. 4th. In fine, by the continued action of boiling water, it gradually melts. I have remarked, that it does not in any period of ebullition, assume the yellowish tinge, which is spread over the whole of the fibrous system when boiled.

From the phenomena that cellular texture offers when exposed to the action of dry and moist air, of cold and boiling water, &c. I presume that it is less easily changed by the gastric juices than many others, the muscular texture, for example; besides, the following facts prove this. 1st. The taste, almost always a certain index which nature has given us to judge of digestible aliments, is much less gratified with the cellular texture that is mixed with cooked meat, than with the meat itself. 2d. I have made this experiment upon myself; when my stomach contained a sufficient quantity of food, I excited vomiting nearly an hour after eating; when it contained but little, I could not vomit without taking a large quantity of warm water; I then threw up this and with it the aliments the stomach contained. I have frequently ascertained by these means, especially by the last, that the cellular lumps which are found with the fleshy fibres of boiled meat, are much longer in being altered than the fibres themselves; these last have become pulpy before the others are acted upon. The fat, which generally fills these cellular lumps, may have an influence also in this phenomenon. 3d. I have made the same observation upon dogs that I have opened at different periods of digestion to determine the difference of the bile in the cystic and hepatic ducts, a difference of which I have already given some account.

How can the cellular texture unite to the softness and delicacy that characterize it, a greater resistance to the different re-agents, than that of other textures much more firm?

We know that in those who are drowned, a great quantity of gas disengaged from different organs, from those especially that contain much blood, as the muscles, the glands, &c. fills the cellular texture, renders it emphysematous and makes the body float. This does not so often take place in the open air, where putrefaction is sudden and where there is a discolouration and disorganization of parts. The tendons, the aponeuroses, the cartilages, the bones, &c. have appeared to me in animals drowned for the purpose, not to assist in the production of this gas. The cellular texture itself has less part in it, I think, than the organs before pointed out. It would be easy to know the kind of gas that each organized system furnishes, by macerating these systems separately in closed vessels, so arranged that their aeriform products might be collected. If each has a peculiar mode of putrefaction and gangrene, &c. if in this state their appearance is different, it is presumable that the products that escape from them are also different.

In dead bodies that are buried, and beyond the reach of the air, the emphysematous swelling often takes place, and it is sometimes so powerful, as I have observed in a church-yard, that it will raise the lid of the coffin, though it may be covered with half a foot of earth, which raises it then above the level of the earth that covers the other coffins.

II. *Parts common to the organization of the cellular system. Blood vessels.*

We must not judge of the vessels of the cellular texture by injections. When they are fine and have succeeded well, a thousand different threads interlaced in

every way, destroy its whitish colour and change it into a vascular net-work. The appearance of a body thus injected is deceptive; it arises from this, that the exhalants have admitted a fluid forced through the arteries, whilst their own sensibility would repulse the blood in an ordinary state. In dissecting the cellular texture upon a living animal, it is seen to be white as in the dead body, and that great trunks that do not belong to it, send off in passing through it different branches and ramifications that are evidently lost in it. In raising the skin from the subjacent organs, the sub-cutaneous texture is distended, and we may clearly distinguish in it different little branches that end there; this is remarkable in dogs. By first making the cellular texture emphysematous, the experiment succeeds better. We see, also, very well in this way, that the blood varies in the vessels; often after being exposed some time to the air, there appears double the number of them there was when it was laid bare. There are always remarkable variations, if the place that is denuded is examined even for a short time; it is the blood retained in the exhalants, and it seems thus to increase the number of little arteries.

Exhalants.

The existence of the exhalants is rendered evident, 1st. by the preceding experiment, which is a natural manner of injecting them; 2d. by artificial injections, which shows there many more vessels than ordinary; 3d. by transudations that sometimes take place in the cells, when these injections are driven with much force, transudations that really form an artificial exhalation; 4th. by natural exhalation, which is continually going on, and which has for its materials the fat and the serum; 5th. by accidental exhalations that sometimes take place, as when the blood is diffused in and colours serous infiltrations, &c.

Few systems in the living economy are furnished with a greater number of exhalants; I do not speak of those that contribute to its nutrition and that are consequently found there as in all other organs. The superabundance of these vessels is owing to the continual exhalation that is going on there. It is this superabundance which renders, as we shall see, inflammation so much more frequent in a part where the cellular texture is in the greatest abundance; it is this that exposes it to that variety of alterations, in which its texture, loaded with the different substances it exhales, has a firm appearance, and offers at one time a fatty substance, at another a gelatinous one, sometimes a species of scirrhus, &c. &c.

Absorbents.

The absorbents correspond with the exhalants in the cellular system; the eye cannot trace them, injections would not reach them. But their existence there is proved, 1st. by the natural and constant absorption of fat and serum; 2d. by the more manifest one that produces resolution of serous infiltrations in dropsies, sanguineous in ecchymosis, purulent in the different kinds of abscesses that are removed; 3d. by the disappearance of mild fluids injected into these cells, an effect that must be owing to the agency of these vessels; 4th. by the resolution of natural and artificial emphysema, in which the air, or at least the principles that constitute it, have no other way of escaping. This is evident when the emphysema arises from a rupture of a bronchial cell, and when a very little opening is made in the animal, it is stopped after the air is driven by it into the sub-cutaneous texture; this I have convinced myself of. 5th. The drying up of external ulcers is owing to the cellular absorbents. Oftentimes in phthisis the ulcers are suddenly emptied, and we find in the subject who dies immediately, only the place that was occupied by pus or sanies; I

have already known two patients to die in this way by a re-absorption almost instantaneous and exactly analogous to that of external ulcers. 6th. Where there is the most cellular texture, we meet with the greatest number of absorbents, and the most of those bodies with a glandular appearance, in which these vessels ramify. Where the cellular texture is scarcely discoverable, as in the brain, we can with difficulty see the absorbent system, &c.

We must consider, then, the cellular system as the principal origin of the absorbents, of those especially which serve to carry the lymph. These vessels and the exhalants appear to contribute particularly to the formation of its structure. Many have thought that it was exclusively formed of them; but this is not founded either upon observation or dissection. We see a transparent filamentous texture, and nothing more. Each cell is a reservoir intermediate between the exhalants that terminate and the absorbents that arise there. They are in a small way what the serous sacs are in a large one. We do not see the orifice of either set of vessels.

Nerves.

We see many nerves running through the cellular texture. But do these filaments stop there? Dissection affords no light upon the subject; it arises perhaps from this, that these filaments being white like the texture, we cannot see them at their termination as well as we can the arterial branches, which are rendered apparent by their colour, when they contain red blood.

ARTICLE FIFTH.

PROPERTIES OF THE CELLULAR SYSTEM.

1. *Properties of texture.*

The properties of texture are strongly characterized in the cellular system.

Extensibility.

Extensibility is proved in a variety of cases, as in œdema, in the accumulation of fat, and in different tumours, in which the cells are much spread and the membranes remarkably elongated. All the natural motions suppose this extensibility ; the arm cannot be raised without the texture of the axilla acquiring an extent double, or even treble, what it has when the arm is down. The flexion and extension of the thigh, of the neck, and of almost all the parts, exhibit in different degrees analogous phenomena. If we raise any organ from those to which it is contiguous, the intermediate texture is considerably elongated.

The degrees of the extensibility of the cellular texture vary. In the sub-cutaneous, the sub-serous, the intermuscular, &c. this property has much more extended limits than in the sub-mucous layer, in that exterior to the arteries, the veins, and the excretories. It exists, however, in this, as is proved by the dilatations of the gastric viscera, aneurisms, varices, &c. But these phenomena themselves prove the greater difficulty of extension in this species of texture ; for example, the ordinary texture would be incapable of resisting the impulse of the blood after the rupture of the coats of the artery. There would be a sudden, enormous, and often fatal dilatation, if the arteries were only surrounded by this.

It is the thickness of that which covers them, which makes the progress of these tumours slow and gradual.

It is in fact an essential character of the extensibility of almost all the cellular system in which the layers and consequently the cells are united, to have the power always of being put suddenly in action and in an instantaneous manner. We have an example of this kind of extension in emphysemas artificially produced, which make this texture go suddenly from a state of perfect contraction to the greatest extension of which it is capable. The artificial injection of different fluids exhibits the same phenomenon. We observe it also as a consequence of fractures, and contusions of the limbs, in which we sometimes see enormous swellings appear in a manner almost as sudden. The cellular texture is evidently the seat of those swellings which take place in that texture which is sub-cutaneous, and not in that subjacent to the aponeuroses, because the extensibility of these membranes not being capable of being suddenly put into action, resists all dilatation that is not gradually made. Many other organs, as the tendons, the cartilages, the bones, &c. though possessing, like the cellular texture, extensibility of texture, differ from it like the aponeuroses, in the impossibility of being suddenly distended. In general, the softness of the primitive structure appears to have great influence upon this modification of extensibility.

The cellular texture, extended too far, becomes at first very thin, and then breaks. In a natural state, no motion of the economy is capable of being carried so far as to occasion this; for example, I have remarked in regard to cellular texture taken from the axilla, that it is necessary to extend it at least three times as far as it is in the elevation of the arm, to produce this phenomenon. Besides, what opposes also this rupture, is a kind of locomotion of which it is capable; so that if too violently

drawn, it displaces that which is contiguous to it, draws it towards itself, and thus becomes less stretched. We see this phenomenon in a remarkable manner in the swellings of the testicle, in large hydrocele. Then all the surrounding texture, that of the lower part of the abdomen, the top of the thighs, and the perinæum, drawn by that which immediately covers the tumour, is thus brought also upon it.

I have observed that the inflamed cellular texture loses in part this property, and that upon the dead body it breaks with great ease. This takes place also in different indurations of which it is the seat. For example, that surrounding a cancerous womb, being swelled, loses the capacity of being extended; it is brittle, if I may be allowed to use the word; the least effort is sufficient to break it. This fact is uniform in all cancerous affections, somewhat advanced, of the womb and in those of many other organs.

Contractility.

Contractility of texture always takes place in the cellular system when extension ceases. Thus in emaciation, in the resolution of dropsy and of tumours, the cells contract and lose a great part of the capacity they had acquired; in a wound which has affected the cellular texture as well as the skin, the edges separate, and a space remains between them owing to the contraction of the cells.

As we advance in life, this contractility takes place with less ease; youth is the period of its greatest energy; thus in consequence of great emaciation that takes place in old men, the skin is flaccid and wrinkled, because the subjacent cellular texture not having contracted, the cutaneous covering remains at some distance from the external organs and cannot lie close to them. In a young man, on the contrary, who has become emaciated, the

skin is exactly applied to the organs, it preserves its tension; because the cells in contracting draw it with them; these form the external prominences. It is necessary to observe these prominences; in the face, with the folds of the skin, they form what are called prominent features.

II. *Vital Properties.*

The animal properties are not among the attributes of the cellular texture in an ordinary state; we can with impunity cut it, draw it in different directions or distend it with gas. An animal that undergoes these experiments gives no indication of suffering. If he feels any pain, it is from the nervous filaments that pass through the texture, and which may be accidentally irritated. In disease however, the sensibility is raised to such a point, that it may become the seat of acute pain; phlegmon is a proof of this.

The organic properties are very distinct in the cellular texture; fat and serum could not be absorbed there, if they did not make an impression that brings into action organic sensibility. I would observe concerning this property considered in the cellular system, that all substances have not an equal relation to it; among the animal fluids the blood, the lymph and milk do not raise it so high, when they are effused or injected there, as to prevent absorption, which takes place of them as well as of fat and serum. On the other hand this sensibility is so altered by the contact of urine, bile, saliva or other fluids destined to be thrown out, that inflammation is often the consequence, and prevents absorption. Among the foreign fluids injected water is absorbed. Wine and almost all other irritating fluids excite suppuration, and are thrown out with the pus that arises from them. We know that in the operation for hydrocele, abscesses in the scrotum are always the consequence of an accidental passage of the injection into the cellular texture. Experiments upon living animals agree

perfectly with this fact; every other irritating fluid, diluted acids, alkaline solutions, &c. produce the same phenomenon.

Insensible organic contractility is clearly proved in the cellular texture, by the exhalation and absorption that take place there.

It has to a certain extent sensible organic contractility. We know that cold alone is sufficent to contract the scrotum in a remarkable manner; that as it is irritated or not, this part has various degrees of contraction and relaxation; now it appears to contain under the skin only cellular texture; the filaments of which, it is true, have a particular appearance and seem to differ in their nature from the filaments of the other portions of this system. This contraction to be sure is not to be compared to that of the muscles, but it is certainly the first degree of it; it is of the same nature, or rather it is a medium between this and those oscillations that cannot be described, which we designate under the name of insensible organic contractility, and others call tone.

Sympathies.

The relations of the cellular with the other systems are very numerous and multiplied; but oftentimes it is not easy to perceive them clearly. In fact, as it is disseminated in all the organs and contributes to the structure of all, it is frequently difficult to distinguish what belongs to it, from that which is an attribute of the parts where it is found. These relations however, become evident under various circumstances; in acute as well as chronic diseases, it is very susceptible of the influence of the affections of the organs. I do not here mean the alterations arising from juxta-position and continuity, alterations so common as we have seen, but those produced in parts of the cellular texture that have not any known relation to the affected organ.

In acute diseases which have their seat in a particular organ, as in the lungs, the stomach, the intestines, &c. the cellular texture is often sympathetically affected; it becomes inflamed, suppurates, &c. Most critical deposits arise from this real though unknown connexion between the affected organ and the cellular texture. Oftentimes it is the natural exhalation or absorption of this texture that is deranged in acute affections; hence the swelling, and dropsies that sometimes suddenly arise. I attended a man in the ward Saint Charles who, in consequence of great terror, had a sudden contraction of the epigastric region; a tinge of the jaundice, an indication of the affection of the liver by the emotion of the mind, spread in a few hours after over his face. In the evening he had great œdema of the lower limbs, an œdema produced, without doubt, sympathetically by the influence of the liver upon the cellular texture. This influence of the principal organs upon this system becomes especially remarkable in chronic affections, in the alterations of texture they experience. We know that most of the gradual diseases of the heart, the lungs, the spleen, the stomach, the liver, the womb, &c. have among their symptoms, in the latter stages, a dropsy more or less general, which arises from the debility created in the cellular texture. Medicine owes much to Corvisart, for being among the first to perceive that almost all infiltrations are symptomatic, that almost all consequently depend upon an influence produced by the affected organ upon the cellular texture. That comes on gradually then, which took place suddenly in the patient I mentioned just now.

We see in all acute diseases, that the skin very easily perceives the sympathetic influence of diseased organs, that it is many times alternately dry or moist, oftentimes in the same day. I am convinced that the cellular texture experiences the same alterations as the skin, and that if we could see what is going on there, we should per-

ceive that its cells are more or less moist, or more or less dry, according to the kind of influence it receives; it is to this also that must be referred the different state of bodies that have died of acute diseases, which present innumerable varieties in their cellular serum.

Most physicians consider in too general a manner a number of symptoms, which, to speak correctly, do not depend as they imagine, upon the disease, but wholly upon a sympathetic affection produced by the diseased organ upon the sound ones, which, according as they are affected, give rise to different phenomena truly foreign to the disease, that sometimes render it complicated but do not form an essential part of it; they can take place or not, and the disease remains the same.

Observe that organic sensibility and contractility are almost always in action in cellular sympathies, because these are the two vital forces essentially predominant in that system. Thus sensible organic contractility and animal contractility are particularly exercised in muscular sympathies, according as the system of organic muscles, or that of the muscles of animal life, receive sympathetic excitement.

The cellular system not only receives the influence of other organs in its sympathies, but it exercises its own upon them. In phlegmon, which is the inflammatory state of this system, if the tumour is considerable, different alterations are oftentimes discoverable in the functions of the brain, the heart, the liver, the stomach, &c. Sympathetic vomiting, which is called an overflow of bile, delirium, &c. are phenomena that are seen with large phlegmonous swellings without belonging to the disease itself. Art avails itself of the influence of the diseased cellular system upon other organs, in the introduction of setons. Oftentimes in diseases of the eyes, a seton produces an effect that cannot be obtained from a blister; why? because the relation that exists between the cel-

lular texture and the eye, is more active than that which unites the latter to the integuments.

Characters of the vital properties.

After what has been said, we see that the vital activity is sufficiently evident in the cellular system. In this point of view, it is much superior to other organs that are white like it, and among which it has been ranked, such as the aponeuroses, the tendons, the cartilages, the ligaments, &c. organs remarkable for the obscurity of their vital forces and the dullness of their functions. Thus the phenomena of inflammation go through their different periods much quicker in this system. Their progress is very rapid, compared to that of different tumours that appear in the systems of which I have just spoken.

Suppuration takes place here with a rapidity of which we have an example in but few of the organs. Every one knows the fluid that comes from this suppuration. Its colour, its consistence, all its external qualities have become the type to which we refer the ideas that we form of pus; so that that which does not resemble it, is considered to be pus of a bad kind, or as we say sanious. This opinion is incorrect. Certainly the pus that flows from a bone, a muscle, the skin in erisypelas, the mucous membranes in catarrh, is of a good kind so long as the inflammation is regularly going through its periods; it is however totally different from cellular pus. As this is most frequently observed, especially in surgery, we have formed a general idea of laudable, as of sanious pus. Cutaneous, mucous, osseous pus, &c. have each their peculiar sanies, which differs among them according to the vital alterations of the organ, from which it is derived. So that the pus of each system differs from that of the others, in the same way as the alterations of which it is susceptible are different from their purulent alterations.

Has the cellular texture peculiar vital modifications in those organs to whose structure it contributes? From what has been said above, it seems hardly probable. All that I have been saying, applies to the system considered in the interstices of the organs, separate from all combination with their structure. It is possible however that its vital activity is diminished in the cartilages, the tendons, &c. that it is increased a little in the skin, that its life, in general tends to an equilibrium with that of the parts in which it is found; but these are conjectures that nothing positive confirms.

That which ought not to escape us here, is the manifest difference of vitality that exists between the texture of layers and filaments almost every where spread, and the texture that is wholly filamentous, which is exterior to the mucous surfaces, to the blood-vessels, and excretories, a difference from which arises the rareness of inflammation and tumours in this last. It is often a real barrier that stops the affections of the first, a barrier that protects the organ it covers. Thus I have many times observed in opening bodies, that whilst the ordinary texture, in which the arteries are embedded as in the axilla, is in a state of suppuration, and almost disorganized by the pus, that which forms the external covering of the vessels remains untouched; it has not undergone the least alteration. I have seen the same phenomenon in the texture exterior to the urethra in deposits of pus at the loins.

III. *Properties of re-production.*

The cellular texture is distinguished from other organs by the faculty it has of throwing out a kind of vegetation, of elongating and re-producing itself, of growing when it has been cut or divided in any manner. It is upon this faculty that depends the formation of cicatrices, tumours, cysts, &c.

Influence of the cellular texture upon the formation of cicatrices.

Cicatrices may be considered under two relations, 1st. in the external organs, in the sub-cutaneous texture and skin particularly; 2d. in the internal organs. Let us examine them at first in the external.

Every wound that follows the ordinary periods, presents between its formation and its cicatrization, the following phenomena; 1st. it inflames; 2d. fleshy granulations are formed upon its surface; 3d. it suppurates; 4th. it sinks down; 5th. it is covered with a fine pellicle, red at first and afterwards becoming whitish. Let us trace these different periods.

First period.

Inflammation commences the instant the wound is made. This is the sudden result of the irritation caused by the instrument, the contact of the air, the dressings and surrounding bodies. Shut out until then from the contact of the air, most of the parts concerned in the solution of continuity, enjoy only organic sensibility; but then these contributing to form the surface of the body, ought to enjoy animal sensibility, that which transmits to the brain the impressions that are received. Now the effect of inflammation upon organs endowed only with the first kind of sensibility, is to raise it so much, that it ascends to the same degree as the second, and can like it, transmit to the brain its impressions; so that by it the parts divided by a wound become capable of performing the functions of the integuments. This is the first advantage, without doubt, of this inflammatory period of cicatrization.

Another advantage of this period is to dispose the parts to the development of fleshy granulations. In fact, inflammation always precedes this development; now the increase of life that it produces in the organs, appears

to be necessary to animate the parts that are to be reproduced; by it the cellular texture, where the granulations are formed, is endowed with more sensibility and more insensible contractility; it raises it to a temperature above that of the neighbouring organs; it becomes the centre of a small circulating system independent of that of the heart. It is in the midst of this extension of the forces, that the fleshy granulations arise and increase, for the production of which the natural forces would have been insufficient. Hence the paleness and flaccidity of these granulations, when these different functions are weakened or cease.

Second period.

The production of fleshy granulations succeeds to inflammation. It presents the following phenomena; small reddish bodies, like tubercles, arise, unequal and irregularly disposed upon the surface of the wound; they are not fleshy, as their name, given, no doubt, on account of their colour, would indicate; they are little cellular vesicles, filled with a thick substance, like lard, which we are unacquainted with, and which it is important to analyze. This substance so fills the cells, that in blowing air into the texture subjacent to a wound, whether in a living or dead body, this fluid does not enter the granulations; they are raised up entire, but no one of them is developed or distended as the cells which this substance does not fill; the granulations remain the same in the midst of the general bloating. I have often made these experiments upon animals that I have wounded for the purpose.

In proportion as the granulations are developed upon an exposed cellular surface, we see them unite together, and form, by their union, a kind of provisional membrane, which absolutely prevents the contact of air upon the subjacent organs, while the true cicatrix, that which is to

be permanent, is forming. This provisional membrane of cicatrices, this kind of epidermis destined to defend the parts during the work of cicatrization, differs from common serous membranes in this, that they are smooth and every where uniform, whilst the granulations produce here an unequal and rough surface. This inequality of the granulations and their separation, appear to be opposed to what I have said concerning the first state of cicatrices; the following experiment leaves no doubt upon the subject. I made a large wound upon a dog, and let it go through its first periods; the animal was then killed. I removed a portion of flesh upon which the granulations were developed; I distended it by a prominent body, placed on the side opposite to the granulations, so as to make the granulated surface convex, that had been concave; the tubercles were effaced; the provisional pellicle, stretched out, became very evident; it might have been taken for an inflamed serous membrane.

It follows hence, that when the granulations are united together, that the air is entirely excluded, and that what is commonly said of the contact of this fluid is inaccurate and contrary to the arrangements of nature, which knows how better than we can do by our dressings, to cover over a divided part, whilst the work of cicatrization is prepared and effected.

These are the general phenomena that cutaneous cicatrices offer in the two first periods of their formation. The internal cicatrices show nearly the same thing. Now it is easy to prove that the cellular system here performs not only an important but an exclusive part, and that all these phenomena take place in its texture or its cells. The following observations prove in a satisfactory manner the cellular nature of the granulations and the provisional pellicle that arises from them. 1st. Where the cellular system is most abundant, as in the cheeks, granulations grow most easily and wounds are soonest

healed. 2d. The skin, stripped too much of the cellular texture, is not covered with ease with these productions, and adheres with difficulty to the neighbouring parts; hence the precept so strongly inculcated in surgery, of saving this texture in dissecting out tumours, in the extirpation of wens, cysts, &c. 3d. Maceration always reduces to this first base the surfaces of granulating wounds, when we expose a dead body that has one to this simple experiment. 4th. The nature of fleshy granulations is the same every where, whatever be the organ that produces them, whether a muscle, a cartilage, the skin, a bone, a ligament, &c.; only they are more or less backward, according as the life of each organ is more or less active, more or less decided, and the vital forces found there marked in a greater or less degree; thus they appear at the end of four or five days upon the skin, and it is very much longer before they are visible upon the bones; but their structure, their external appearance, their nature, are always the same; then they are only the expansion, the enlargement of an organ, that is met with in all the others; now this organ common to all, this general base of every organized part, is the cellular texture.

From the red colour of fleshy granulations, it has been thought that they were a vascular expansion; but their development is unlike every production of the blood-vessels. On the one hand we have seen, that the cellular texture contains so many exhalants and absorbents, that it seems to be almost made up of them; on the other hand, we shall see that in inflammation a passage is constantly given to red blood in this kind of vessels; then, as the fleshy granulations are cellular, they consequently partake of the nature of this system; and when found in a real inflammatory state, we conceive that their redness is the same as that of an inflamed pleura, of the cellular texture that has become the seat of phlegmon, of erisy-

pelatous skin, &c.; a redness that does not imply an elongation of blood vessels, but only the passage of red blood, in those that usually carry white. This is so true, that when the inflammation is gone, the blood ceasing to enter these vessels, the membrane takes its natural colour; so that the granulations, after the formation of the cicatrix that arises from their near approach to each other, whiten because the blood no longer enters them. Now if it had been a new production of vessels, they would continue and perform their functions. Moreover, how can we suppose a development of blood-vessels where they did not primarily exist, as in the tendons, the cartilages, &c. which have, like other organs, fleshy granulations in their solutions of continuity?

Let us conclude from these circumstances, that the arterial system is not connected with the formation of fleshy granulations; that the cellular system is alone concerned in it, because that this alone is endowed with the faculty of increasing, extending, and reproducing itself.

This is what takes place in the second period of the cicatrization of wounds; the cellular texture, by the increase of power that it acquired in the first period, is raised into vesicles irregularly disposed, which exhale a white substance, that is not well understood, and unite at their superficies and form a provisional membrane. But how is this membrane changed into that of the cicatrix? Observe nature, and you will see that it brings on suppuration and a sinking down of the parts, before the arrival of this period.

Third period.

The period of suppuration does not take place in the cicatrization of the bones, in that of broken cartilages, of torn muscles and generally in the reunion of all divided organs without external wounds. We must then show what relation there is between their cicatrices and those

of the external organs; for a common principle presides over all the operations of nature, though they may have a different appearance.

When a bone is broken, the two first periods of its reunion are the same as those of the external organs; the ends inflame, and then are covered with cellular granulations. In the third period, these granulations, having first united together, become a kind of secretory or rather exhalant organ, which separates first the gelatine which encrusts it, and gives to the callus a cartilaginous nature, and then the phosphate of lime which completes the osseous arrangement. In the cicatrization of cartilages, gelatine only is exhaled; in that of the divided muscles, fibrin, &c.; in a word the cellular texture is the common base of all the cicatrices of the internal organs, then the fleshy granulations are the same for all; they resemble each other in each having the same base; that which establishes the difference between them, is the substance that is separated, and which remains in the cellular texture. This substance is generally the same as that which serves for the nutrition of the organ, and which is by this function, constantly carried there and brought away. Now as each organ of the different systems has its peculiar nutritive substance, each has its peculiar mode of reunion; we should understand the cicatrization of the different organs, as well as that of the bones, if the substances that nourish these organs were as well known as gelatine and phosphate of lime. The mode of development of the internal cicatrices is in general analogous to that of nutrition, or rather it is the same with this difference only, that the cellular texture rising into irregular granulations upon the divided surfaces, does not afford to the cicatrix a base formed upon the shape of the organ; hence the inequality of callus, &c.

This then is what in general takes place in the third period of the cicatrization of the internal organs: phe-

nomena very analogous are seen in that of the external. The membrane which covers the fleshy granulations thus becomes a kind of exhalant organ which separates from the blood a whitish fluid that is called pus. But there is this difference, that instead of remaining in the texture of the granulations, of penetrating and encrusting it, as the phosphate of lime and gelatine penetrate the bone, it is thrown out and has nothing to do with the reunion; so that in internal cicatrization there is exhalation, then incrustation[*] of the exhaled fluid, and in the external, there is exhalation and then excretion of this fluid.

Besides, an internal wound which affects the cellular texture and suppurates, appears to me to resemble perfectly serous surfaces, which are covered in consequence of their inflammation with a purulent exudation. The fine pellicle that covers the granulations is of the same nature as an inflamed pleura or peritoneum, that is, it is essentially cellular. The pus is in both cases almost of the same nature, and analogous to that of phlegmon, because it comes from similar organs, whilst if the skin alone is concerned, this fluid is of a very different nature, as we see in erisypelas.

The exhalation of pus upon a cicatrizing surface and serous membranes, appears to me to have a great analogy with the whitish substance of some kinds of cysts.

Fourth period.

Suppuration gradually exhausts the whitish substance that fills the granulations; then their cells, which were at first swelled, insensibly diminish in size, they close by their contractility of texture; by degrees they adhere to each other, and from their adherence arise the following phenomena. 1st. All the fleshy tubercles disappear and there is a uniform surface in their place. 2d. This surface is a very fine membrane, because the thickness of the granulations arose not from the cells, but the substance

they contained, and which being taken away, leaves them empty. 3d. This membrane has infinitely less width than the pellicle that first covered the granulations, because the cells in contracting, draw the edges of the cicatrix from the circumference to the centre; these approximate, and the breadth of the wound diminishes; the same granulations that in the beginning occupied a space of half a foot diameter, as for example in the operation for cancer, are often contracted to an inch or two.

When the adhesion is complete between all the cells that first form the fleshy granulations, the membrane of the cicatrix, the result of this adhesion, exists. Thus it is that all the flesh, the development of which astonishes us, and which amply repairs the loss of substance, is but a pellicle, reddish when the exhalants are full of blood, but afterwards white by the return of this blood into its vessels.

From this mode of origin of external cicatrices, it is easy to conceive, 1st. why they adhere intimately to the places in which they are found, and have no laxity in the integuments; 2d. why the skin approximates from all the neighbouring parts to cover the wound; 3d. why it wrinkles in approximating; 4th. why, where it yields the most, the cicatrix is the smallest, as in the scrotum, the axilla, &c.; and why on the contrary it is the largest, where it yields but little, as on the sternum, the cranium, the great trochanter, &c.; 5th. why the thickness of all cicatrices is uniformly in an inverse ratio to their width; in fact as there is only the same quantity of cellular granulations to form them, it is necessary that they should lose in one way what they gain in another; hence those that are broad are much more easily torn; 6th. why they have not a regular organization, do not partake of the functions of the cutaneous organ they replace, and why their texture is absolutely different from this organ. The

cicatrization of wounds left to themselves, especially those with loss of substance, differs essentially from the union by the first intention, which is effected by the agglutination of the edges. In this last there is neither the second period, that of fleshy granulations, nor the third, that of suppuration, nor the fourth, that of sinking down. Union succeeds immediately to the first, that of inflammation.

We see, from all that has been said, that the cellular texture is the essential agent in the production of all cicatrices, that it forms their basis and their principle, that without it they could not take place, and that they depend especially upon the property it has of extending and increasing.

Influence of the cellular texture in the formation of tumours.

In the formation of cicatrices, the cellular texture grows but a few lines above the level of the place of division; the cells it forms in its reproduction are generally small. It is not so when there is a departure from the ordinary laws of cicatrization, when any accidental cause alters the vital properties; then we see a very extensive growth, which often has more of this texture than the parts from which it arises. All those different excresences, known by the names of fungous flesh, fleshy protuberances, soft flesh, &c. are but the result of this increase of the cellular system, being greater than what it should be by the ordinary laws of cicatrization; thus the cicatrices are not effected while these irregular productions continue; it is not until they are repressed that consolidation takes place. But it is especially in different tumours that we see this development, this remarkable growth of cellular texture. All the fungi, and productions that are developed exclusively in the mucous membranes, in the sinuses, the nasal cavities, the mouth and the womb particularly, and which differ essentially from those that have their

seat on the fibrous membranes, the dura-mater for example, though they are compounded under a common name, all the fungi, I say, arise from the cellular texture, they are of a peculiar substance deposited there, which as it is more or less abundantly separated, leaves its primitive base more or less exposed.

Polypi, whether mucous or sarcomatous, tumours that are equally the attribute of the mucous system, have also the cellular texture for the primitive base of their organization. All the different kinds of cancers exhibit it in a manner more or less evident, in the swelling of the parts which they occasion. It would be necessary to notice almost all tumours, to point out those that the cellular texture assists to form.

We may then consider it as forming the general base, the nutritive parenchyma of almost all excrescences. It shoots up, and grows first at the part where the tumour is to be developed; then it is encrusted with different foreign substances, and their difference constitutes the difference of the tumours. These phenomena are precisely analogous to those of ordinary nutrition. In fact, all the organs resemble each other in their nutritive base, the parenchyma of nutrition, which is vascular and cellular; they differ in the nutritive substances deposited in this parenchyma. All tumours then are cellular, this is their common character. Their peculiar character is derived from the substances that the texture separates, according as the morbid alterations of which it is the seat, modify differently its vital forces and place it in relation with this or that substance; thus as we have said, all the internal cicatrices are similar in the first period, in that of fleshy granulations, and differ as the nutritive substance of the organ to which they belong, penetrates them.

Thus we see, that nature is the same in her operations, that a uniform law presides over all, and the only difference arises from the application of this law. Wherever

there is natural nutrition or an accidental modification of this function, the cellular texture performs an essential part; now this important part which it has in cicatrization and the formation of tumours, arises from the singular property it possesses of extending itself, of dilating and growing. Examine the tumours that appear in the muscles, the tendons, the cartilages, &c. you will not see there an expansion of fleshy, or tendinous fibres, or of the cartilaginous substance, &c. the cellular texture alone goes from the organ and is spread in the tumour; thus the fibres of the bones, the muscles, the fibrous substances divided in solutions of continuity, are not raised above the level of the wound, as the cellular texture of the part is for the production of granulations.

The tumours of which I have spoken, have nothing in common, as has been imagined, with the acute swellings that constitute phlegmon, nor with that engorgement that the limbs experience where there is a violent irritation, as a compound fracture or luxation, a whitlow, a puncture with a poisoned weapon, &c. an engorgement that is generally seen around the whole external parts, which are violently affected; it sometimes comes on almost instantaneously, and is not really inflammatory, though there is tension, pain, &c.; it deserves rather the name of inflation than engorgement.

We must not confound these tumours with certain chronic swellings, in which, without increasing or growing, the cellular texture is infiltrated, and different substances enter it, that change its nature; such are those that take place in the diseases of the articulations; such is the callosity of fistulas, &c.; the fatty matter that is found in some tumours, &c. In all these cases there is neither growth or enlargement, as in a polypus, a fungus, &c.; it is a substance more solid than serum, that infiltrates the cellular texture, obliterates its layers, and presents a homogeneous appearance.

There is after death a great difference between an acute and chronic tumour, between that produced by growth and that by infiltration. In fact, one remains the same, and preserves, until putrefaction, its size, its form, and its density, like all the organs. The other sinks away, as I have remarked, by the loss of the vital forces. This subsidence varies; if the tumour is nothing but the cellular inflation of which I have spoken, and which is so common in external injuries, it entirely disappears; if, besides this inflation, there is an accumulation of blood, as in carbuncle, phlegmon, &c. a portion of the tumour remains, though always much diminished in size. It is generally in this inflation, of the immediate cause of which I am ignorant, that the subsidence especially takes place. Let us pass to a function of the cellular texture not less important, and which is very analogous to this.

Influence of the cellular texture in the formation of cysts.

A cyst is a membrane, in the form of a sac without an opening, which is accidentally developed, and which, containing fluids of a different nature, has been on this account divided into many species. The cysts are formed from the cellular texture; they arise in its cells, grow in the midst of them, and have all its characteristics.

To be convinced of the influence of the cellular system in the formation of cysts, it is sufficient to prove that between them and the serous membranes, there is the greatest analogy, and almost identity; for we shall see that these membranes are essentially cellular. The following are some of the analogies of these two kinds of productions, the one of which is natural and the other accidental.

1. Analogy of conformation. The cysts form all kinds of sacs without an opening, containing a fluid that is exhaled from them, having a smooth, polished surface con-

tiguous to this fluid, an uneven, loose one, continuous with the neighbouring cellular texture.

2. Analogy of structure. Always formed of a single layer, like serous membranes, cysts have like them a cellular texture, as is proved by maceration and inflation. Thus they constantly arise in the midst of the cellular organ, usually where it is most abundant. Few blood-vessels enter them; the exhalant system is conspicuous there.

3. Analogy of the vital properties. There is no animal sensibility in them in an ordinary state, but it is very evident in inflammation; organic sensibility is always remarkable in them, and tone, which is characterized by a slow and gradual contraction, in consequence of the artificial or natural evacuation of the contained fluids, &c.; these are the characters of cysts, they are also, as we have seen, those of serous membranes.

4. Analogy of functions. Cysts are evidently secretory or rather exhalant organs, which exhale the fluid they contain. Exhalation becomes very evident there, when after the evacuation of the fluids, the membranous sac has not been removed, or an artificial inflammation excited in it. Absorption is proved, in the spontaneous cure of encysted dropsies, a cure which must depend on this function alone.

5. Analogy of affections. Who does not know that between the dropsy of the tunica vaginalis and the encysted dropsy of the cord, there is the greatest analogy; that the curative means are the same, that in both cases the inflammation that is produced by the injection of a foreign fluid, wine, for example, is the same, and that the cure is effected by a similar mechanism? Whoever has opened two bodies, each having one of these affections, and examined the sacs in which the fluid is contained, must have perceived that their appearance is precisely the same. Remove the fluid from the cyst of a

soft wen, and you will discover but little difference between it, dropsical cysts, and serous membranes.

The preceding considerations induce us to admit a perfect resemblance between cysts and serous membranes, of whose characters they partake, and into the system of which they essentially enter, and consequently into the cellular system. It is very probable that there is a relation between them, and that when a cyst is formed and exhales copiously, the exhalation of the serous membranes is diminished; this does not, however, rest upon direct proof. There is this essential question, how are these cysts developed? How a membrane, which does not exist in a natural state, can arise, grow, and even acquire a very considerable development under certain circumstances. This problem is usually resolved in the following manner; at first, it is said, a small quantity of fluid collects in a cell; this fluid increases and dilates in every direction, the parietes of the cell, which are attached to the neighbouring cells and thus increased in thickness. Gradually this fluid, serous in dropsy, white and thick in steatoma, &c. increases in quantity, presses in every direction the sac that contains it, enlarges, crowds against the neighbouring organs, and thus acquires the form under which we see it. Nothing at first sight appears more simple than this mechanical explanation; nothing is less conformable to the process of nature. The following considerations will serve to prove this. 1st. The cysts are analogous in every point of view to serous membranes; how then could they have a different origin from these membranes, which are never formed, as we shall see, by the compression of the cellular texture? 2d. Does an origin thus mechanical, in which the vessels compressed against each other would inevitably be obliterated, as we see the skin become callous, accord with the exhaling and absorbing function of the cysts and with their peculiar kind of inflammation? 3d. Why, if the cells adher-

ing to each other, form these unnatural sacs, is not the neighbouring cellular texture diminished and destroyed, even when they acquire great size? 4th. If, on the one hand, the cysts are formed by the compression of the cellular texture, and if it is true on the other, as we cannot doubt, that their fluid is exhaled by them, it is necessary to conclude then, that this fluid pre-exists in the organ that separates it from the blood: I would as soon assert that the saliva pre-existed in the parotid, &c.

The immediate consequence of the preceding reflections, I think, is, that the common explanation of the formation of cysts, is directly opposite to the general course that nature pursues in her operations. How, then, do these sacs arise and grow? these tumours that appear externally, or are developed within; for there is no difference in these two sorts of unnatural productions, except in the form. Most tumours throw from their external surface the fluid that is separated there. A cyst, on the contrary, exhales this fluid by its internal surface, and preserves it in its cavity. Suppose a fungous, suppurating tumour, suddenly becomes a cavity, and suppuration is carried from the external surface to the walls of this cavity; this will be a cyst. On the other hand, suppose a superficial cyst, the cavity of which is obliterated, and the fluid of which is exhaled upon the external surface; this will be then a suppurating tumour.

As the form, then, establishes the only difference between tumours and cysts, why should not the formation of one be analogous to that of the other? Surely, no one ever thought of attributing to compression, the formation of external or internal tumours. We may conceive of the production of cysts in the following way; they begin to be developed and grow in the midst of the cellular organ, by laws very analogous to those of the general increase of our organs, and which seem to be aberrations, and unnatural applications of these fundamental laws, of

which we are ignorant. When the cyst is once characterized, exhalation commences; at first scanty, it afterwards increases as the cyst grows. The increase of the exhalant organ, then, always precedes the accumulation of the exhaled fluid, so that other things being equal, the quantity of suppuration in a tumour is in a direct ratio to its size.

ARTICLE SIXTH.

DEVELOPMENT OF THE CELLULAR TEXTURE.

I. *State of the cellular system in the first age.*

In the first periods after conception, the fœtus is only a mucous mass, homogeneous in appearance, and in which the cellular texture seems almost exclusively to predominate. In fact, when the organs begin to be developed in this mass, the spaces that are left between them are filled with a substance which, exactly similar to that which before formed the whole of the body, can be considered as the residue of it, or rather perhaps it exists in a distinct manner, because it has not been penetrated with the peculiar nutritive substance, like that which forms the parenchyma of nutrition of the organs, which before this penetration resembled it precisely. This substance that lies between the organs, and which is the principle of the cellular texture, is the farther removed from a fluid state, as the period of labour approaches. First it is a true mucus, then a kind of glue, then the cellular texture begins to appear.

This primitive state of the cellular organ, this appearance that it has at first, is owing to the great quantity of fluids that enter it at that period; it does not denote an

inorganic existence; we can then compare it to the vitreous humour, which appears wholly fluid at first sight, because the transparency of its layers do not permit us to see them in the humour that enters its cells; make a puncture so as to evacuate this humour, and they become evident.

Thus the cellular texture, extremely fine and even transparent in the first periods of life, is then concealed by the humour that fills it, and becomes more sensible as this humour diminishes with age. This phenomenon sometimes takes place in after life, in different serous infiltrations, those especially in which the infiltrated fluid has some viscidity.

What is this humour that is so abundant in the cellular system, in the first months after conception? Is it albuminous like that which afterwards lubricates it? Probably it is; I should think, also, that it has much of the character of gelatine, a character which predominates, we know, in the animal humours at this period; I know of no experiment upon this point. Whatever the humour is, it is much more viscid and unctuous than it is afterwards; the touch is sufficient to convince us of this. It is its predominance, joined to the delicacy of the cellular layers, that, in the first months, makes every attempt to render the fœtus emphysematous, by blowing air under the skin, almost absolutely useless.

At birth and some time after, the great quantity of sub-cutaneous fat makes artificial emphysema very difficult; it does not appear that the fœtus ever has a natural one. The delicacy of the cellular layers and filaments is such at this period, that the imagination cannot represent it; the texture of the hair is gross in comparison with it. I presume that the ball of fat, which I have said almost always exists in the cheek of the fœtus, arises from a rupture of several layers, a rupture from which is produced a great cell, that is filled with fat.

Sometime before birth, at that period and in the subsequent years, the cellular humour constantly diminishes; the cells become dryer, consequently more apparent; the whole mass of the cellular system diminishes, because as the organs increase, the interstices are contracted. This system however predominates for a long time over the others; hence the roundness of form that characterizes the infant, the want of prominence of its organs, that are almost concealed by it; hence in part the suppleness and multiplicity of its movements; hence also the frequent diseases of which it is the seat at that age.

The layers still preserve an extreme delicacy; they are still easily broken. In producing emphysema, upon very lean children, I have observed that often it forms in places very considerable dilatations, a kind of sacs in which the air accumulates in large quantity, and which arises from this rupture; whilst in the same experiment upon an adult, the air is propagated in an uniform manner and constantly infiltrates the cells without destroying them. By comparing in our slaughter-houses, the flesh of calves blown, and that of oxen in the same state, I have sometimes made an analogous observation.

In infancy and in youth, the vital energy of the cellular texture is very conspicuous; at this age, the fleshy granulations, essentially cellular as we have seen, arise more promptly and go through their periods more rapidly than at any other age; the union of wounds is easier; and all tumours, have in their development and their progress, a rapidity that particularly depends upon the high degree to which the vital forces of the cellular system are raised at this period. It is to the same cause, that must be referred the facility of absorption of serous fluid, which sometimes infiltrates accidentally the cells, as we see in the scrotum, the eye-lids, &c.; the suddenness of the formation of cysts, &c.; then dropsies are much less frequent. When they do take place, why are the superior

extremities almost as often affected as the inferior, whilst the leucophlegmasia of adults commences almost always in the last ? This is then as remarkable a phenomenon, as the singular tendency that there is in the legs of being infiltrated, compared with the arms. Does not this depend upon situation, which, forcing the lymph to ascend against its weight, gradually weakens the absorbents when it has continued for some time ? This explains, why varices are, as we know, more frequent in the inferior than superior extremities.

II. *State of the cellular system in the after ages.*

In the adult, the cellular texture is condensed and becomes firmer; its layers have a more compact texture. It appears also to lessen in quantity, because as the organs increase in thickness, their interstices are contracted. If there is not a real diminution, there is at least one in comparison with the state of the organs. It is to this circumstance that must be attributed in part, their prominence under the integuments, the striking appearance of the form of the muscles, &c. It appears besides, that the quantity of cellular texture varies according to temperaments; that in those called phlegmatic or lymphatic, it predominates over the other systems, and in the bilious, which is characterized by a dryness and rigidity of fibre, it is in the smallest proportion. In women, it is in larger quantity than in men ; the roundness of their forms is in part the result of this.

The motion of a part appears to have no effect in producing a more active nutrition of its cellular texture, as takes place in the muscles, the nerves, and sometimes even in the blood-vessels.

In old age this texture is condensed and contracted ; it acquires consistence and hardness. The teeth tear it with difficulty in the boiled flesh of old animals ; like it, it is tough and requires long boiling to soften it. Much

less fluid is exhaled there, hence a sort of dryness and rigidity, that render the motions of old age difficult. A kind of withering, that it experiences, contributes essentially to the general diminution that the body then undergoes. It loses its vital forces; hence its laxity, that prevents it from supporting the skin as usual. This becomes every where loose, dependent even in some places, in which it forms folds. The scrotum has no longer the power of contracting that characterized it and which it derived from the forces of the cellular system. This general relaxation, this sort of flaccidity is the constant attendant of old age, in individuals even in whom excess of all kinds, or a primitive disposition, have rendered this age premature. I saw at the Medical Society a dwarf, sixteen years of age, hardly two feet high, who had already begun to grow old; his sub-cutaneous texture had that laxity, that does not belong to his age. The premature decrepitude of the dwarf of the king of Poland, exhibited the same phenomenon. Two persons who lived a long time with him informed me, that at his death, there was externally this relaxation and flaccidity of integuments, of which the subjacent cellular texture appears to be the seat.

It is rare in old age to find osseous incrustations in the cellular texture. In the great number of old persons that I have had occasion to dissect, or to have dissected, I remember to have seen but one, and that occupied the posterior part of the mesentery. I have seen some others in adults, especially in women, in whom they are found frequently, in the cellular texture that separates the womb from the rectum; I have preserved several specimens of these.

NERVOUS SYSTEM OF ANIMAL LIFE.

ALL anatomists have heretofore considered the nervous system in an uniform manner; but if we reflect a little upon the forms, the distribution, the texture, the properties and the uses of the different branches that compose it, it is easy to see that they should be referred to two general systems, essentially distinct from each other, the one having the brain and its dependancies for its principal centre, and the other, having the ganglions. The first belongs especially to animal life; it is on the one hand the agent, that transmits to the brain the external impressions that are to produce sensations; and on the other it serves as a conductor of the volitions of this organ, which are executed by the voluntary muscles to which it goes. The second, almost every where distributed to the organs of digestion, of circulation, of respiration, of the secretions, belongs more particularly to organic life, in which it performs a part much more obscure than that of the preceding one. Neither is strictly confined to the organs of either life. Thus the cerebral nerves send some branches to the glands, to the involuntary muscles, &c.; and the nervous system of the ganglions have ramifications in the voluntary muscles. It is from the general arrangement, without regard to particular exceptions, that the division of the two nervous systems is founded, between which I shall not draw a parallel here to show their difference, because the description of each will be sufficient to do this.

The nervous system of animal life is exactly symmetrical, like all the organs of that life. The brain and spinal marrow, which are the double origin of this system, have this character in a remarkable degree. Nerves precisely similar go from them; hence the name of pair, by which is designated the double, corresponding trunk, a name, that we should not be able to employ commonly in the system of ganglions. There are then really two nervous systems of animal life, the one right, the other left; the median line separates them. Their distinction is apparent not only from dissection, but from their diseases. At one time exactly one half of the body is deprived of motion, and the whole nervous system of that side remains passive, the other retaining its ordinary activity; at another, one side only has an unnatural energy and becomes the seat of convulsions, while the other remains calm. In both cases, sometimes the phenomenon is general; often it is limited to a greater or less number of lateral organs; but always there is an evident separation between the two nervous systems, the right and left. The kind of partial paralysis, of which I just spoke, and the principal character of which arises from the symmetry of the nervous system of animal life, is wholly different, as it regards this character, from that in which the lower parts of the body are deprived of motion in consequence of a fall upon the sacrum, or any other analogous cause.

The relations of size of the nervous system with the brain are in man and most quadrupeds, in an inverse proportion, as has been observed by Soemmering. In man the brain is much more voluminous than in the others, who have nerves larger than his. It is easy to prove this assertion, in all the animals that we commonly employ for our experiments; in fact, small dogs are used, on account of the size of their nerves in very delicate experiments upon sensibility. This difference is a striking proof of the superiority of man, as it respects the intellectual

phenomena, which are all referable to the encephalic mass. On the other hand, many animals are superior to him as it respects motions and the four senses of taste, of smell, of hearing and seeing. Observe however that he surpasses them all in the perfection of the fifth sense, viz. that of touch. Why? Because this sense is entirely different from the others, is consequent to them, and corrects their errors. We touch, because we have seen, heard, tasted and smelt. This sense is voluntary; it supposes reflection in the animal that exercises it, the others do not. Light, sounds, &c. strike the respective organs without any effort of the animal; but he touches nothing without a preliminary act of the intellectual functions. It is not then astonishing, that the perfection of the organs of touch and the great development of the brain, should be in man, in the same proportion, and that in those animals, in whom the brain is more contracted, the touch should be more obtuse and the organs less perfect.

ARTICLE FIRST.

EXTERNAL FORMS OF THE NERVOUS SYSTEM OF ANIMAL LIFE.

I shall consider these forms, 1st. in the origin; 2d. in the course; 3d. in the termination of the cerebral nerves.

I. *Origin of the cerebral nerves.*

The word origin should only be understood in relation to anatomical arrangement. In fact, the nerves are formed at the same time as the brain; they are rather organs of communication with this viscus, than elongations of it. If we take a view of the functions of one part of the nervous system, we shall see that the termination is at the brain, and the origin is upon the surface. Is it

not said that the nerves go towards this or that part, that the arteries take this course, wind about, &c.? These are only metaphorical expressions, the least reflection will determine their meaning.

The nerves of animal life derive their origin from three principal portions of the encephalic mass; 1st. from the cerebrum; 2d. from the Tuber Annulare or Pons Varolii and its elongations; 3d. from the spinal marrow; the cerebellum gives origin to none. This circumstance, which, we ought not to lose sight of in the examination of the functions of each part of the brain, and which will perhaps hereafter elucidate these functions, is undoubtedly sufficient to make us appreciate the opinion of many physicians of the last age, which placed in the cerebellum the source of involuntary motions, and attributed the voluntary to the cerebrum.

The cerebrum furnishes but two nerves, the olfactory and optic; these are remarkable, 1st. in this, that their adhesion is very strong at their origin with the brain, and that by raising the pia mater, we cannot remove them; 2d. in this, that their softness is greater than that of most other nerves.

The tuber annulare and its elongations, as well those that go to the cerebrum and the cerebellum, as that which begins the spinal marrow, furnish the motores communes of the muscles of the eye, the pathetic, the origin of which, though posterior, is evidently derived from the tuber annulare, the trigemini, the motores externi of the eye, the facial, the auditory, the par vagum, the glosso-pharyngeal and the great hypo-glossal. All these nerves are distinguished by different characteristics. 1st. As the medullary substance, is every where exterior to the eminences from which they arise, all appear manifestly to be continuous with this substance. 2d. Almost all begin by many filaments separated from each other; sometimes, as in the trigemini and par vagum, these are very numerous.

The others arise, some by one filament and others by two. 3d. Except the auditory nerve, all have a greater consistence at their origin than these last. 4th. They adhere but little to the corresponding cerebral portion, so that they are almost always raised in detaching the pia mater; thus it requires great precaution, to prevent breaking the nerves from the brain when it is taken out of the skull. The adhesion of the pathetic, the motores communes and the facial, is particularly weak. We should almost say, from a slight examination, that there was only contiguity.

The spinal marrow gives origin to thirty or thirty-one pair of nerves, viz. eight cervical, twelve dorsal, five lumbar, five or six sacral, and to a nerve that enters the cranium and goes out of it under the name of spinal. The following are the characters of these nerves at their origin. 1st. They are continuous, like the preceding, with the medullary substance. 2d. They all arise by two cords, one anterior, the other posterior. These cords derive their origin from many filaments, placed above each other, most usually separate and always distinct. 3d. The adhesion is much stronger at the origin of these nerves than at that of the preceding, a circumstance that depends upon a cause that will be hereafter pointed out. 4th. The consistence of the spinal nerves is also very evident in their canals.

From what has been said, it is clear, that the nerves do not arise deep in the cerebral substance, at least in an apparent manner, but take their origin from its external surface. Many physiologists however, have admitted an origin more remote than can be proved by examination. They have believed that the nerves of one side arise from the opposite, and that each pair cross each other not only in the brain, but also in the spinal marrow. This opinion is founded upon a singular phenomenon, viz. this, that paralysis almost always takes place on that side which is

opposite to the affected side of the brain, a phenomenon that is frequently noticed in diseases and proved also by experiments, as has been shown by Lorry. On the other hand, it is said that convulsions are seated in the side corresponding with the injured side of the brain; but this fact is more uncertain than that of paralysis, which is incontestable. I do not believe that with our present knowledge we can explain this last, and the anatomical opinion pointed out above, is contradicted at the first sight.

I will make but one observation upon this singular phenomenon, and that is, that it particularly concerns the nerves of motion, and hardly ever affects the nerves of sensation. In fact we know, that in wounds of the head, in consequence of apoplexy, &c. one eye, one ear, one side of the tongue, one nostril, do not become insensible, as the muscles of one side cease to move. We do not suddenly become paralytic on one side as it regards sensation, as we do as it respects motion in hemiplegia. Experiments cannot elucidate this, for it is impossible to perceive the alterations of sensibility as we do those of mobility. However, by compressing the brain of a dog, and thus rendering him paralytic on one side, and then shutting each eye separately and alternately, to see if he distinguished objects, and afterwards by presenting in turn to each nostril volatile ammonia, or other pungent substances, I have not seen, as it regarded the sensibility, an alteration corresponding with that which the mobility experienced. We often observe in man a discordance in the organs of sense. One ear hears better than the other, one eye sees further, &c.; hence false hearing, hence a species of strabismus, &c.; but the cause of these discordances appears to reside in the organ itself, and not to be connected with the brain.

Moreover, it does not appear that each hemisphere always corresponds necessarily with the nerves of motion

of the opposite side. In fact, we often see on the right side effusions or injuries of the cerebral substance, without any alterations of motion on the left, and vice versa.

The following are the cerebral membranes that are found at the origin of the nerves; 1st. the dura mater forms for them a kind of canal in the fissure through which they go out, then it quits them entirely, and is partly lost in the cellular texture, and the remainder is reflected upon the edges of the opening and continued with the periosteum. The optic nerve is the only exception to this; it is accompanied in its whole course by a fibrous canal, which goes even to the sclerotic coat, which in this way, communicates with the dura mater. 2d. The tunica arachnoides surrounds every nerve at its origin with a fold formed oftentimes in the shape of a tunnel, the broadest part of which is at the origin. By carefully raising the brain, or by opening the dura mater of the spinal canal, we very easily discover this fold, which is continued to the osseous opening, through which the dura mater enters, it is then reflected upon the surface of this membrane corresponding with the brain, forming a sac between it and the nerve. Sometimes, as in the optic nerve and the motor externus, it penetrates the fibrous canal of the dura mater, and accompanies the nerve to the middle of the canal, which, consequently, is lined in part by the tunica arachnoides, and partly by the cellular texture. 3d. The pia mater is used in a manner that is difficult to understand, and which has not as yet been well explained. I shall speak of its continuity upon the nerves, in treating of their peculiar membrane.

The nerves go over a more or less considerable extent before going out of the cranium or the spinal canal. 1st. The two that arise from the cerebrum are much longer within than without. 2d. Among those of the tuber annulare and its dependancies, the pathetic nerves are the only ones that remain any length of time in the

cranium before they go out of it, and that have a greater extent there than externally; all the others go out almost immediately. 3d. The nerves of the spine have a much greater extent when examined lower down. Above, they become directly external; below, they are six inches long in the canal, and consequently pass many foramina before they arrive at their own; hence it happens, as has been observed by Jadelot, that if we avail ourselves of the spinous processes, on account of their prominence, to judge of the origin of the nerves in the application of the moxa, it is necessary, in the neck, in order to act upon a point corresponding with the origin of any nerve in particular, to take nearly the spinous process of the vertebra that corresponds numerically with the pair that we have in view, whilst in the loins it is much above this vertebra that the application should be made.

The direction of nerves at their origin is also very variable. At the cerebrum and the tuber annulare, there is no general arrangement. But in the spinal nerves, this direction, almost perpendicular to the marrow above the cervical region, always becomes more and more oblique down to the end of the lumbar region. These three things, viz. the length in the canal, the size and oblique direction of the spinal nerves, successively increase from above downwards in a gradual manner, with some exceptions as to size.

Each pair of nerves, in going from the cerebrum, the tuber annulare or its dependancies, and the spinal marrow, diverges in the two trunks which form the pair. The olfactories alone converge, and the spinal run nearly parallel.

II. *Course of the cerebral nerves.*

The nerves exhibit different arrangements at their exit from the osseous cavities that contain their origin.

Communication of the cerebral nerves at their exit from their osseous cavities.

1st. The two nerves of the cerebrum, go without communicating with any other, to their respective destination. 2d. Those of the tuber annulare and its dependancies begin to have communications, which are much more evident when examined inferiorly. Thus the par vagum and the great hypo-glossal nerves, send in going from their respective foramina, numerous filaments to the neighbouring organs, whilst above, the motores communes, the pathetici and even the trigemini shew this arrangement less evidently; the auditory nerve does not communicate with any other. 3d. The communications of the nerves of the spine are more evident at their exit, especially in their anterior portion. The deep cervical plexus, the brachial, lumbar, and sciatic, arise from these communications, which are not so visible in the intercostal nerves.

These kinds of plexuses have a particular arrangement. They are formed in the following manner; each nerve, at its exit from the foramen, sends a branch above and below, and also receives one; so that the cords that succeed those that go from the foramina, arise from two or three of these. These second cords, in dividing, send branches above and below, receive them and form third cords; so that in the brachial plexus, for example, when the nerves cease to communicate thus, and are divided into separate trunks, that each may go to its destination, it would be impossible to say correctly from which pairs they arise. It would require a very tedious dissection to ascertain precisely from what pairs come the median, the cubital, &c.

It is this consideration that has induced me not to describe the nerves of the spine as it is usually done, that is, as going from such or such pairs. I describe at first in each region the plexus that the nerves form there in going out of the spine; thus, I expose before the cervical nerves,

the deep cervical plexus, before the brachial the brachial plexus, and before the lumbar and sacral the plexuses of the same name. The general arrangement, the form, the relations of these plexuses being known, I pass to the description of the nerves that go from them before, behind, without, within, &c. without regard to the pairs of nerves that come through the foramina. This method has appeared to me, moreover, to be extremely convenient for students. Nothing, for example, is more complicated than the description of the cervical nerves, by referring them to the pairs that first furnished them. But understand well at first the deep plexus, arising from the anastomoses of these pairs at their exit; afterwards class the nerves, 1st. into internal, which go to the great sympathetic; 2d. into external, which are distributed upon the acromion and the triangular space, bounded in front by the sterno-mastoideus and behind by the trapezius; 3d. into anterior, which, winding upon the sterno-mastoideus, form there with the branches of the facial a kind of superficial plexus; 4th. into posterior, which go either to the occiput, or to the posterior muscles of the neck; 5th. into those that go inferiorly, as the diaphragmatic, as those that communicate with the nervous branches of the hypo-glossal, &c. &c. In this way, you will easily retain all the nervous distributions, because you will have one point to which your memory will refer them all, and not to as many centres as there are pairs.

Internal communications of the nervous cords.

It is not only at their exit that the spinal nerves thus communicate. The different cords of which each nerve is formed have precisely the same arrangement, as may be easily seen in the great trunks, as in the median, the cubital, the radial and especially the sciatic. By separating the different cords of these nerves, we see that they are not only in apposition longitudinally, but that

they send numerous filaments to each other. These communications do not resemble those of the arteries, in which there is always continuity between the communicating branches. Here there is only contiguity, and each of the cords forming the nervous trunk is, as we shall see, composed of filaments; now it is these filaments that frequently go from the cord to which they belong to a neighbouring one; so that after a short distance, the cords that began the nerve are not composed of the same filaments as those that finish it; the whole becomes mingled together in the course of the nerve. Thus the cords of the branches of the brachial plexus, at its origin, are not arranged like those of the branches that terminate it. For there is this difference between the very evident plexuses formed by the nerves themselves and those that are less evident formed during their course in their interior even, viz. that in the first, it is the cords that go off and form the interlacing, and in the second it is the filaments. I once amused myself in tracing the filaments of the sciatic for a short distance; now those which composed above the external cords, were found for the most part below in the cords of the centre.

This remark proves that there are not nervous cords destined to sensation and others to motion, and that if the same nerves do not serve the double use, the difference is in the filaments, and not in the cords.

In the interior of the vertebral canal, in which the nervous cords are much insulated, for the want of cellular texture, the filaments that compose them do not thus communicate with each other; there is not, as without, a plexus in the interior of the nerve. This is remarked particularly at the extremity of the canal, where the nerves run a long course, as I have before said.

The communication of the nerves at their exit from their osseous cavities is so general, that under this point of view it may be said that they form on every side a

kind of organ every where continuous, an organ to which the optic, the olfactory, and the auditory nerves only are strangers.

Besides, these kinds of communications, which are all made by juxta-position, do not appear to have much influence upon the functions of the nerves. Each of their cords, though belonging in its course to many different trunks, can perform its functions in an insulated manner; so can each filament, though concurring in its course to form many cords of the same nerve.

I would observe with regard to this, that it is necessary to distinguish accurately these communications from anastomoses, in which two nervous filaments coming in an opposite direction, are confounded and identified with each other, which is seen between those of the facial, the sub-orbitary, the mental, &c.

Nervous trunks.

After having thus communicated at their exit, the nerves separate from each other and go towards the different organs. They form at first considerable trunks, which pass through the great cellular interstices and go over a greater or less extent. The form of these trunks is sometimes flattened as in the sciatic; but it is most commonly rounded; but the form does not affect nervous action, for the nerves that are naturally round, when flattened by a tumour, perform their functions as usual. In general, whenever it does not interfere with her design, nature chooses the round form for the organs of animals. I would observe also. that this form requires a system generally diffused. and destined to fill up the spaces that necessarily exist between round organs; this system is the cellular. It would be infinitely less necessary, if the form of our organs was square, because there would be less space between them.

The nervous trunks are of different length. Those of the extremities hold the first rank in this respect, because the extremities being very distant from the origin of the nerves, these trunks must of course go over a certain extent before distributing their filaments. In the trunk and the head, on the other hand, as the organs are presented immediately to the nerves that enter them, the division into branches is immediate, and the trunks are very short.

The nervous trunks are sometimes accompanied by a corresponding arterial and venous trunk, as the brachial, crural trunks, &c.; at other times, as the sciatics, and those of the par vagum, they go separate.

Of the nervous branches, &c.

As the trunks advance, they furnish here and there different branches; these give out smaller ones, which send off those that are still smaller, from which arise the last divisions. All these different divisions take place at very different angles. The acute angle is the most common. It is not a real origin, but merely a separation of many cords united, that forms the branches, of one or two of these for the smaller ones, of one cord only for the still smaller, and of separate filaments for the last divisions. Thus this separation is made more or less high, in different subjects. The place where it happens is never exactly determined.

According to these divisions, the filaments which compose the cords of each nerve and these cords themselves, are of different lengths; the shortest separate first, then the middling; in fine, the longest filaments of all go the whole extent of the nerve, and only terminate where it ends. The brachial and crural nerves exhibit this arrangement in a remarkable manner.

The nervous branches are almost all accompanied by an artery and a vein, especially in the extremities; for in

the trunk, there are exceptions to this rule; in the neck, for example, the arteries often cross the nerves at an angle, instead of accompanying them in their course. In the head, many arterial branches are found thus separated from the nervous. This circumstance is sufficient to make us attach less importance than some authors have done, to this juxta-position of the nervous and sanguineous systems. Moreover, if this juxta-position was so essential, it would be seen with regard to the smaller branches; but this never happens.

III. *Termination of the nerves.*

I call that the termination, where each filament ends and not that only where the whole trunk of the nerves terminates; so that the sciatic terminates at the thigh, at the leg and at the foot, and not merely at the extremity of this last. In fine, after what has been said already and from what will be said further, the union of filaments into cords and that of cords into trunks, is an arrangement disconnected with their functions, and each filament should be examined separately. The filaments of nerves have three different terminations. They are continued, 1st. with other filaments of the same system; 2d. with the filaments of the system of the ganglions; hence arise anastomoses. 3d. They are lost in the organs.

Anastomoses with the same system.

I have already observed, that true anastomoses should be distinguished, from the junction of a cord that passes to a nerve more or less remote from that to which it belongs, and which simply places itself by the side of its filaments, so that it contributes with them to the nervous cords. Thus there is no anastomosis in a plexus, in the union of the chord of the tympanum with the lingual nerve, &c. So that though the filaments of the different cords of a nerve pass frequently from one to the other, so

as to give to the nerve a net-work-like texture, and not as anatomists say, a simple thread-like texture, still it cannot be said that the cords of the same nerve anastomose with each other; there is only juxta-position. On the other hand, the communication of the great hypo-glossal with the cervical pairs, forms a true anastomosis, because there is a continuity, and not merely contiguity of nervous filaments.

If those physicians, who have considered the anastomosis as the exclusive causes of all sympathy, had reflected how few they are in comparison with what they appear at first view, they would have been, by this simple reflection, led to a different opinion. In fact, it is very evident, that though a filament is joined to a trunk, it has no more relation to the filaments of that trunk, than these have among themselves; that is to say, that there is nothing in common but the cellular covering. The arterial and venous anastomoses are infinitely more numerous than the nervous. I believe that they can perform a part in neuralgia, in some sympathies even, a part foreign to the simple communications of the filaments.

We can generally refer anastomoses to three classes. 1st. Two branches belonging to different nerves, go on together, as in the example cited above of the great hypoglossal, and as also the branches of the facial with those of the sub-orbitary, the occipital with the frontal, &c. 2d. The branches of the same nerve can unite together, as those of the three portions of the trigemini. 3d. Sometimes the two nerves of the same pair, or those of two different pairs, but coming from the two halves of the nervous system, unite at the median line; some examples of this may be seen in the superficial nerves of the neck, in those of the chin, &c. This union does not take place upon the abdomen, where the median line, entirely aponeurotic, has no nervous branch in its texture. It is perhaps by these anastomoses that take place at the median

line, that we may explain, how certain motions can still continue in a part affected with paralysis. This sort of anastomosis is in general very rare. In the extremities it is evident, that they cannot exist ; in the trunk, they are hardly ever seen behind, and not frequently before. If every pair of nerves gave examples of them, it is clear that hemiplegia would rarely take place, because the sound side of the brain or spinal marrow would through them have an influence upon the nerves of the affected side.

Anastomoses with the system of organic life.

This termination has a great analogy with the preceding, since there are two nerves, which meeting at their extremity, are blended in such a manner, that we cannot tell where one begins, or the other ends. I shall treat of this in the following system.

Termination in the organs.

The exposition of the following systems will show us the varieties that exist as it respects the nerves. 1st. In some there are many of them, as in the mucous, dermoid and muscular systems of animal and organic life. 2d. In others we find fewer of them, as in the cellular, glandular systems, &c. 3d. Some require a more attentive examination than has heretofore been made of their nerves, which are little known, as the serous, the medullary, a portion of the fibrous, &c. 4th. In fine, many, as the cartilaginous, the fibro-cartilaginous, the pilous, the epidermoid, the tendons of the fibrous, &c. are evidently destitute of nerves.

We are ignorant of the situation of each nervous filament at its termination ; is it deprived of its covering, and does the pulp only penetrate the interior of the fibres ? In the optic nerve this last arrangement is evident. The covering of the nerve is continued only to the en-

trance of the eye, and the pulp is expanded to form the retina. A similar expansion seems to take place in the olfactory and the auditory. But nothing is known concerning any of the others.

ARTICLE SECOND.

ORGANIZATION OF THE NERVOUS SYSTEM OF ANIMAL LIFE.

I. *Texture peculiar to this organization.*

Every nerve is formed, as I have said, of a greater or less number of cords lying in apposition to each other. These cords arise from filaments likewise in apposition and united together, like the cords by cellular texture. I have already mentioned how both are interlaced in the interior of the nerve, so as to form a kind of plexus, which differs from the true plexus only in this, that the branches applied to each other, do not allow us at first view to see their intermixing.

The general character of the nervous cords varies considerably. 1st. Their size is not always the same. Those of the sciatic and the crural are smaller than those of the brachial nerves, except those of the median. 2d. Some nerves, as the par vagum, are formed of one cord only, divided by many furrows. Sometimes the filaments form around it a net-work, a very delicate kind of plexus. 3d. In the same nerve, there is sometimes united large and small cords; in many they are all equal, as in the sciatic. 4th. The optic nerve, though furrowed in its whole extent, from the commissure to the eye, does not appear to have in its interior that interlacing, that the others evidently exhibit. 5th. In the posterior part of this nerve, and in the trunk of the olfactory, the cords are not distinct. 5th. Most of their nerves at their origin are

separate in their filaments; the trigemini on the contrary, exhibit a common pulpous portion, in which all their's seem to be implanted, &c.

It follows from all these considerations and many others for which we are indebted especially to Reil, that the internal arrangement of the nerves varies singularly, that each presents almost a different texture, that under this point of view they do not resemble the arteries and veins, which are every where the same, whatever be their size, their course, &c. These varieties however, do not affect the intimate structure, and our business is to describe this intimate structure even to the last fibres that we can separate. Reil appears to me to have thrown great light upon this subject. I have repeated exactly his experiments; they have given results very analogous to his. Some only have appeared to me so difficult, that I have not even undertaken them. I have added to his researches many new facts as will be easily seen by comparing his work with this article, in which will only be found that which rests on accurate observation; I have omitted all the theoretical ideas that Reil has added to the facts which he offers.

We distinguish two things in every nervous filament, 1st. an external membrane in form of a canal, in which is contained the medulla; 2d. the nervous medulla itself; I shall now treat of each separately.

Of the nervous coat and its origin.

This membrane forms for each nervous filament a true canal which contains in its interior the medulla; as the veins and arteries contain the blood, with this difference, that this medulla is stagnant, while the blood circulates.

The origin of the nervous coat is very evident at the spinal marrow. It is continued with the dense and compact membrane which covers its white substance, and which is called the pia mater, though it does not resem-

ble the membrane of that name which surrounds the cerebral circumvolutions. To see this origin well, this spinal membrane should be cut longitudinally before or behind. The medulla then appears whitish, soft and easily raised up. If it is raised and scraped with a scalpel or any other instrument, the immediate covering of the spinal marrow is thus separated from either side, especially if precaution be taken to wash it. It might be had in the form of a sac, by cutting out a piece of the medulla of a certain extent and then pressing out the medullary substance at the two ends. In this double experiment, the nerves remain attached to the membrane separated from its medullary substance, because their nervous coat is continued with it. It is exactly as if a number of small arterial filaments went from the aorta; the parietes of this artery would be to those of these filaments, what the pia mater of the spinal marrow is to the coat of the nerves which go from it. Only the nerves are white, because their medulla fills them; whereas the canal to which they belong is transparent, because it is deprived of its own medulla. I do not pretend however, that there is a perfect identity between these two membranes, since we do not exactly know the nature of either; I refer only to their anatomical arrangement.

As to the origin of the nerves contained in the cranium, those coming from the tuber-annulare and its dependancies, that is to say, the elongations that it receives from the cerebrum and cerebellum, have an arrangement analogous to that of the nerves of the spine. However, the difference of thickness and density of the pia mater establishes differences. In fact the pia mater which covers these parts is different from that which serves as a canal to the spinal marrow; it is much softer, less adherent, is torn with more ease, and appears to be analogous to that which covers the cortical substance of the brain. The coat of the nerves of the tuber annulare, which is

manifestly continued from this portion of the pia mater, exhibits partly this character. At the place of their union, it is more soft than in the canal, hence the extreme facility with which, as I have observed, the origin of these nerves is broken. Moreover, the continuity with the pia mater is proved by the facility of raising the nerves by raising this membrane; almost always both are attached together.

As to the nerves of the cerebrum, the olfactory, loosely covered by the pia mater, does not appear to have a coat of its own. The optic is evidently destitute of it from its origin to its junction with that of the opposite side. Then it begins to be covered with it; and canals are formed by it, filled with medullary substance, and which continue even to the retina. Besides, this nerve differs singularly from the others, 1st. because it has a kind of general nervous coat; 2d. because its medullary substance is more abundant and more easily obtained, its canals being larger; 3d. because these canals, pressed against each other, give it the appearance in the interior of a continued body; but by cutting it longitudinally, it is easy to see that the medullary substance is separated there by partitions. The auditory nerve has also a very peculiar texture.

From what has been said, it is evident that the pia mater has greater analogy with the coat of the nerves, than any of the other membranes; it may be said to be almost the same in the spinal canal. Observe, in fine, that this membrane, which has never yet been well described, evidently presents three great modifications, according as it is examined; 1st. upon the grey substance that surrounds the whole of the cerebrum and cerebellum, where it is reddish, extremely vascular, loose, slightly resisting. and very easily raised; 2d. upon the white substance that covers anteriorly and posteriorly the tuber annulare and the four great elongations that it receives from the cerebrum and the cerebellum, where it is less

red and where it begins to become more firm, more adherent, and less easily torn; 3d. upon the whole spinal marrow and upon the corpora pyramidalia and olivaria. It is thickened and condensed at the furrow that separates these eminences from the tuber annulare, then, increasing in thickness below, becoming whitish, resisting, &c. it has an appearance entirely different from what it had in the cranium. It might be said to be a membrane wholly different. It has four times the thickness of the tunica arachnoides.

In most of the subjects that I have examined it is much stretched, and compresses, if it may be so said, the medullary substance for which it serves as a canal; so that when a small opening is made in it the medullary substance immediately comes out. But I presume that it is looser during life. Besides, this state of compression is much less sensible towards the superior part than towards the middle and inferior, on account of the difference of thickness. I would remark, that the density of the pia mater of the spine is necessary to prevent injuries of the medullary substance, which is very soft at one part, and which at another is smaller than the diameter of the canal; so that it can be shaken there; an arrangement wholly different from that of the brain, which completely fills the cranium.

Arising in the manner we have pointed out, the coat of the nerves passes with them through the cavity of the cranium and that of the spine. It is very distinct in these cavities, because it is not surrounded there with cellular texture, but only with the arachnoides, which may be raised with great ease; instead of using the different preparations that Reil mentions for the purpose of separating the coat of the nerves from the cellular texture, it is infinitely more convenient to examine this membrane upon the last nerves of the spine, which are, as we have seen, remarkably long.

Action of certain substances upon the nervous coat; its resistance, &c.

Without the osseous cavities, the nervous coat embedded in the cellular substance, adheres to it strongly, but appears evidently to be of the same nature as in the interior. We are ignorant what its nature is, whether it is the same as that of the pia mater, of the medulla, of the tuber annulare and its dependancies. It appears to have great affinity with the cellular texture. It is transparent and consequently free from the colour of the nerves; hence why, when they have been deprived, by alkalies, of their pulp, they lose a great part of their whiteness.

The coat of the nerves is one of the parts of the animal economy which are hardened with the greatest ease, especially at the instant the nerves are immersed in an acid slightly concentrated, particularly the nitric and sulphuric. I have not observed in any other texture this phenomenon in so remarkable a manner; the nerve is suddenly diminished in size and twisted in different directions; now we shall see that the medullary substance is in no way concerned in this phenomenon. The action of boiling water produces an analogous effect; by it the nerve is wrinkled, contracted and hardened; then, after the ebullition has continued for a certain time, it gradually becomes soft, and its whitish colour is changed to a sort of yellowish tint, very different from that of boiled tendon or aponeurosis. The action of the acids continued for some time, produces an effect analogous to that of ebullition. To the sudden hardening like horn which the nerve undergoes, soon succeeds a softness so great that at the end of a short time it is easily moved under the finger, and afterwards becomes partly dissolved.

The alkalies do not produce the horny hardening in the nervous coat any more than in any other texture of the living economy; neither do they dissolve it. Hence,

undoubtedly, why Reil, having macerated for some time a portion of nerve in soap-boilers lie, was able to separate accurately the nervous coat from its medullary substance.

The action of water upon the nervous coat produces a phenomenon that is exhibited by few others of the animal textures. Far from softening it immediately and then reducing it to pulp, it seems in the beginning to increase its consistence. A nerve soaked in water becomes there harder and more resisting, and this state, at the ordinary temperature of cellars, continues for a month and a half, and even two months. It is only at the end of this time and frequently longer, that the texture of the nervous coat is gradually softened, and broken, and finally ends by being diffused like other macerated textures. I have not repeated this experiment in a very warm temperature, which has always succeeded in that of winter and spring.

The coat of the nervous filaments has a very great resistance, because it is, in proportion to the medullary substance that it contains, infinitely thicker than the membranous canal of the spinal marrow. It is thus that the proportion between the thickness of the vascular parietes and the fluids they contain, is much less in the great trunks than in the small branches; the fluid considerably exceeds the solid in the first, there is at least an equality in the second. Thus a very small nerve would support a much greater weight than the spinal marrow. I believe that among the textures which are arranged in filaments or in elongated tubes, this and the arterial, next to the fibrous, afford the greatest resistance; they surpass the venous, the muscular, the serous, &c.

Medullary substance; its origin.

This substance occupies the interior of the nervous canal, in the same way as the substance of the spinal

marrow fills the canal formed by the pia mater. This medullary substance is whitish, as that of the brain and spinal marrow; it gives the nerve its colour. It is in much greater proportion in the optic nerve than in any other; it is found exclusively in that part of it posterior to the junction of the two, as well as in the olfactory. It is so abundant in the auditory that it seems to form a great part of it. In general, I think at the origin in the osseous cavities, it predominates over the nervous coat, but in the course of the nerve, the nervous coat is the greatest. Hence the greater degree of resistance of the nerves in the second, compared to what they have in the first.

This substance appears to be continuous with the medulla of the brain, the tuber annulare and its dependancies, and the spinal marrow. I think, no one can deny this continuity with the origin of the optic and olfactory nerves, in which more of this medullary substance is found than in the other nerves. In the auditory, also, it is very apparent; in the spinal marrow, by scraping this white substance from the internal surface of the pia mater, so as to leave the nerves adhering to this membrane, we see evidently at the place where these nerves go off, that there is an elongation penetrating their nervous coat.

Comparison between the medullary substance of the brain and the nerves.

What is the nature of the medullary substance of the nerves? I have endeavoured to institute a comparison between it and the cerebral substance; there is considerable analogy under some points of view and some difference under others.

1st. Submitted to drying in the open air, in small slices to prevent putrefaction, the white substance of the brain becomes yellow, and acquires considerable consistence. The nerve dried becomes yellow also, hardens and con-

tracts. These changes are undoubtedly owing in part to its coat. The proof of this is that if we dry the covering that the pia mater furnishes to the spinal marrow, a covering that has great analogy to the nervous coat, the new qualities it acquires are very analogous to those of the dried nerves. But this does not prevent the medullary substance of the nerve from contributing also to the yellow colour by the evaporation of its watery part. I will make, in regard to this, a remark that I think interesting; it is this, that water has an influence upon the whiteness of a number of textures which become yellow or greyish by its subtraction, and are whitened again by its addition. Thus we have the power of making yellow, by drying, all the fibrous organs, the skin, &c. and of restoring them afterwards to their primitive colour. Thus also the serous surfaces, the cellular texture, &c. that have become greyish from drying, regain their whiteness when immersed in water, if they have not been long dried. The epidermis of the sole of the foot and the palm of the hand turns from grey to white, when it has been immersed for some time in water.

2d. The cerebral substance and that of the spinal medulla easily become putrid when submitted to the combined action of water and air; they become of a greenish colour and have acid sufficient to redden blue paper. Of all animal substances, I think they exhibit this phenomenon the soonest. The nervous medullary substance, on the contrary, resists putrefaction much longer. The nerves are among the slowest of all the parts of the animal economy to become putrid. During life they are often found untouched in a gangrenous limb, in the middle of an abscess, &c. In a dead body which is putrid, they preserve their whiteness and consistence, while the other parts are black and soft. I have observed that the water in which the nervous system has been macerated has but little odour, but that that in which the brain has

been macerated is fœtid. These phenomena clearly would not take place if the medullary substance of the nerve became as easily putrid as that of the brain. It is manifest, however, that it is especially to the nervous coat, that the nerves owe this sort of incorruptibility; for I have observed, that the optic nerve, in which the medullary substance predominates, and the olfactory and auditory, which are abundantly furnished with it, become putrid sooner than the others. I have remarked also uniformly, that whilst the white substance of the spinal marrow becomes putrid, its covering remains untouched.

3d. The medullary substance of the nerves, as well as that of the brain and spinal marrow, does not seem to be susceptible of any kind of horny hardening. This is very evident when we immerse the two last in boiling water, in a concentrated acid, &c. We may be convinced as to the first, by submitting to the same experiment the soft nerves that have their nervous coat pretty distinct. To this also must be referred the following phenomenon; when the anterior part of the optic nerve is put into boiling water, the nervous coat becomes wrinkled, its canals shrink, and the medullary substance not contracting in proportion, is forced towards the extremities, which become consequently enlarged. As this substance is in less proportion in the other nerves, this phenomenon is less apparent in them; it takes place, however, and this explains the small round tubercle that is seen at each end of boiled nervous filaments; it is the medullary substance that produces these enlargements. This phenomenon is very evident in the spinal marrow, which, being immersed in boiling water, suffers the compressed substance to escape, either at the extremities, or at any openings that may be made in its covering. Thus in boiling a head, the dura mater detached from the cranium contracts powerfully in hardening like horn, compresses the cerebral substance which does not contract

like it, and sometimes breaks it, so that it escapes into the space that the boiling has produced between the dura mater and the cranium.

4th. When the cerebral substance is agitated in water, it becomes suspended in it in the form of an emulsion, as has been observed by Fourcroy, then it is precipitated to the bottom of the vessel. A similar emulsion is made by the olfactory nerves, the posterior part of the optics, &c. When the anterior part of these, in which the nervous coat is very evident, has been soaked some time in water, and commonly even without this, a large quantity of whitish substance can be pressed out of them, which is evidently analogous to the medulla of the brain, and which colours the water that receives it. From the other nerves in which the medullary substance is much less abundant, it can often be forced out by pressure, from the cut ends of the filaments, especially if they have been previously macerated in an alkaline solution.

5th. Boiling hardens the brain, and gives it a greyish and dingy appearance, very similar to what is seen in ataxic fevers. The same phenomenon takes place in the soft nerves. In the others, the nervous coat is in too great a proportion to the medullary substance to allow us to see what happens to this last. It is to this property of coagulating by heat, which the brain has, that must be referred the flaky precipitate that is obtained in a heated cerebral emulsion.

6th. All the acids that are much concentrated harden the brain very evidently, the instant it is immersed in them. The sulphuric afterwards softens it, and finally reduces it to pulp, if it is not diluted. The nitric makes it yellow only, in hardening it. The muriatic has the least action upon it. The effect of acids upon the soft nerves is very analogous to this. In those in which the coat is very distinct, the horny hardening of which this coat is the seat, conceals all the sudden phenomena rela-

tive to the medullary substance. When the coat is softened and dissolved, this substance has appeared to me to be diminished in consistence and altered by the acids, whereas that of the brain keeps always the same degree of hardness, if the acid be not too much concentrated.

We all know that alkohol hardens the brain. This hardening, the effect of acids, of boiling, and of alkohol, is a phenomenon that the anatomist can avail himself of to give the parts he dissects a firmness, that will enable him to examine them better. It approximates this substance to the albuminous fluids. I say that it approximates it, for there are still great differences between them, of which, I think, we know but little.

7th. The alkalies have an effect upon the cerebral substance precisely opposite to that of the acids. They make it fluid, and even dissolve it completely after a short time. I have observed, with regard to this, that the grey substance is much quicker altered by them than the white, which is softened, disappears in part, but still leaves a considerable portion that is not dissolved. From whatever part we take these two substances to submit them to the action of the alkalies, the result is the same. The alkalies act also evidently upon the medullary substance of the nerves. This action, as I have said, has been of great assistance to Reil in his experiments.

8th. Thouret and Fourcroy have discovered, that the brain, after being buried, lessens considerably in size, and changes to a brittle substance, capable of softening under the finger, miscible in water, exhaling a disagreeable odour, having the properties of ammoniacal soap, and resembling very closely spermaceti in its nature. Do the nerves undergo a similar alteration in their medullary substance? We know nothing at present by which we can determine this question.

9th. The muriate of soda, when sprinkled upon slices of the brain and the pulpy nerves, increases their consistence.

10th. The digestive juices generally alter with ease the medullary substance of the brain. I think, however, that they would have a much more powerful action upon it in a natural than a boiled state; for all the re-agents are in general more powerful in the first of these states. We know that most carnivorous animals esteem the cerebral substance delicious food. Those that feed upon birds, the parietes of whose craniums are easily broken, almost always eat the brain first. The weasel, the pole-cat, &c. furnish examples of this. Man considers the brain as one of the most dainty parts of the animal. The nerves are much less easily digested; but this depends wholly upon their coat, which does not yield so readily to boiling as the other parts. For example, the tendons, which are as hard or harder than the nerves in a natural state, become much softer by boiling. We can distinguish in boiled meat each of these parts. The first, in its gelatinous state, is more pleasant and digestible.

11th. The cerebral medullary substance is very different in the brain, the tuber annulare and its elongations, and the spinal marrow. If we examine it attentively, in all these we must perceive the difference in colour, consistence, hardness, humidity, and, without doubt also in its very nature, though our knowledge is not yet sufficiently advanced to decide with certainty upon this last point. Has the nervous medullary substance analogous differences? I believe that it is similar in the same nerve, but that it varies in different nerves according to their uses. In fact, when the internal arrangement of the cords and the filaments which constitute the nerve, differs so much, when there are varieties in the nervous coat also, why should the medullary substance be every where of the same nature? Certainly the colour

and consistence of that of the olfactory are different from that which is forced out from the anterior part of the optic. That of the auditory does not resemble that of the trigemini, &c. We have seen that each of the organs of sense has its peculiar sensibility, which places it exclusively in relation with particular bodies in nature, that of the eye with light, that of the ear with sounds, &c. I think that these differences of sensibility depend upon the difference of organs; but I am persuaded that the organization of the nerves has much influence, and that the optic nerve would be unfit to transmit tastes, the auditory to propagate impressions made by light, &c. If we examine attentively, we shall see an essential difference of structure between the nerve of the eye, of the nostrils, the ear, and that of the taste, which approximates, in thickness, the nerves of motion. As to the nerves of touch, they do not require a peculiar texture; for I shall prove hereafter that a particular kind of animal sensibility is not necessary for this sense, but that this general property is sufficient for it, since its accuracy depends especially upon the mechanical form of the hand. As to the nerves that go to the voluntary muscles, as these muscles are every where analogous and perform similar functions, I think their medullary substance is the same. But in the par vagum, whose destination is so different, why do not the varieties of internal organization coincide with that of the texture which we observe in dissecting this nerve? We may say the same of many nerves that go to parts whose sensibility presents an entirely different modification.

This then is a comparison between the cerebral pulp and the medullary substance of the nerves, which may throw some light upon their difference and their analogy. I have not availed myself of all the details of the chemical experiments that have heretofore been made upon the brain; I have only given the principal phenomena of

the action of different re-agents, phenomena, all of which I have repeatedly proved.

The medullary substance of the nerves is not arranged in filaments. It appears to be analogous to the white substance of the spinal marrow which is a real jelly, stagnant in the canal of the pia mater, which serves as a reservoir for it. Besides, examination proves this assertion in the optic, auditory, olfactory nerves, &c. In general I think, that this substance, as well as the cerebral, would be ranked, if they were deprived of the vessels that run through them, rather among the fluids than the solids, or they would form a medium of connexion between the two.

II. *Parts common to the organization of the nervous system of animal life.*

Cellular texture.

The nerves are entirely destitute of this texture in the interior of the cranium, and the spine ; but out of these they have a great quantity of it. A large external layer, first covers and then connects them with the neighbouring parts. This layer is looser than that which surrounds the arteries. Fat often accumulates in it ; sometimes, though rarely it is the seat of dropsical effusions.

From this common layer go off different elongations which communicate with the cellular texture of the neighbouring organs, and form a medium of union between the nerve and these organs. Within, there are other elongations that go between the nervous cords, and separate them from each other, and form for them kind of canals. When a nerve has been macerated some time in diluted nitric acid, the cords become separated from their sheath, which is to them what the layer of which we have spoken is to the whole nerve. These cellular canals often contain also fat in the great nerves, in the sciatic there is always

some of it. Hence it is that when we dry these organs, there is almost always as I have observed, a fatty exhalation upon their surface; and that, when they are immersed in any alkaline solution, they have evidently an unctuous and truly saponaceous deposit.

Finally new elongations going from the cellular canals that surround the cords, cover the nervous filaments with canals still smaller. Here, there is never any fat or serum, and the cellular texture has in part that peculiar nature which characterizes the sub-arterial, the sub-nervous texture, &c.; perhaps even the nervous coat is nothing but this texture considerably condensed. Besides, the cellular texture so connects the one to the other, the cords of the nerves, and the filaments of these cords, that no motion can take place there.

Blood vessels.

Each nerve receives its vessels from the surrounding trunks, which send to it branches which penetrate from all sides to the interior. The optic is an exception to this rule; the membrane that surrounds it prevents the vessels from entering it laterally. An artery passes through it in the course of its axis and sends out different branches.

In the other nerves, the arteries run first in the cellular texture between the cords, and are of a size there more or less considerable, according to the nervous trunks. Sometimes this size increases considerably. For example, in popliteal aneurism, the artery of the sciatic nerve has been seen with a caliber more than three times its natural size.

The arteries running between the cords, send off a number of little branches that go into all the interstices of the filaments. In fine, from these arise the little capillary arteries which are spread upon the coat of the nerve, cross it and are continued with the exhalants of the medullary substance. We readily see this vascular arrange-

ment in the spinal marrow. Numerous ramifications are spread first upon the dense and firm pia mater, which there takes the place of the nervous coat; they then penetrate the medullary substance, and are lost in continuation with the exhalants.

The veins follow in the nerves a course analogous to the arteries; however, in carefully dissecting many great nervous trunks, I have been convinced that their branches do not go out of the nerves at the place where the arteries enter. This arrangement is analogous to that of the brain, where the arteries enter below and the veins go out above.

Many authors, particularly Reil, have overrated the quantity of blood that goes to the nerves, because, in order to ascertain it, they have made use of fine injections which have entered the capillary system, which does not commonly contain red blood. I am convinced by dissecting the nerves of living animals, the only means of having an accurate idea of what takes place in a natural state, how uncertain this method is here as every where else.

The blood that goes to the nerves, like that which is sent to the brain, is a stimulant that supports their action. When this stimulant is increased the nervous excitability increases, as Reil was convinced by rubbing the nerves of a frog, so as to redden them by the quantity of blood that was brought there. Does this fluid, when carried in great quantity to the nervous system, sometimes interrupt its functions, as happens to the brain in sanguineous apoplexy? I have not had an opportunity yet of making this observation in a very decided manner in the great number of bodies that I have opened. Only the nerves are a little more reddish in some cases than others. Do these cases coincide with certain determinate diseases? I have not any knowledge upon this point. As to the pretended compression of the origin of the nerves, by the blood that is carried to the brain and spinal marrow, who-

ever has examined the relations of the nerves with the vessels of the base of the cranium, will see that such a compression is not probable. Besides, most of the holes through which the little arteries penetrate into the interior even of this viscus, have a caliber greater than that of the arteries; so that how full soever they may be, they cannot press upon their parietes. I can only conceive of a compression at the origin of the nerves, from effusions at the base of the cranium.

Exhalants and absorbents.

We cannot discover these vessels in the nerves; but nutrition supposes their existence there. It appears that this function is performed in the following manner; the exhalants receive from the arteries, with which they are continuous, the medullary substance which they deposit in the canal of the nervous coat, which is, if I may so express myself the reservoir of this substance, that is afterwards taken up by the absorbents.

Many think that the nervous coat is the secretory organ of this medullary substance, which oozes out of its parietes, to lie in its cavity. I do not believe it, 1st. because the olfactory nerve would not then be able to support itself, any more than the posterior portion of the optic. 2d. The cerebral membranes are not concerned with the secretion of the pulp of the brain, they only permit the vessels to pass, which enter this organ to deposit it there. 3d. There is the same arrangement at the spinal marrow, the pia mater of which has so great an analogy with the nervous coat. The vessels cross this membrane, then losing themselves, as I have said, in the medullary substance constantly renew it; so that if it was possible to remove this substance without touching the vessels, these would hang loose by their extremities in the canal of the pia mater. Thus, in some very soft fungi, the vessels cross here and there the substance that they deposit in their

interstices, and would produce a vegetation like net-work, if we could remove this substance and leave them untouched. 4th. In the optic nerve the vessels evidently are not confined to the nervous coat; they penetrate also the canals it forms, and deposit there the medullary substance.

Every thing appears then to prove, that the nervous coat is no more the secretory organ of the nervous substance, than the pia mater is of the cerebral substances or that of the spinal marrow. It may have uses of which we are ignorant; but the principal certainly is that of a covering; it is the passive part of the nerve, the medulla being the part essentially active.

From this way of describing the production of the nervous medullary substance, it is evident that it does not proceed from the brain, but that it is formed in each nerve by the means of the neighbouring vessels. Hence why the inferior portion of a cut nerve does not decay; why a ligature that interrupts the cerebral communications, does not prevent the nervous nutrition; why in most paralyses in which the nervous system ceases to correspond with this organ, it is supported as usual.

From these and other considerations, Reil considers the nerves as having an entirely insulated existence, as being bodies by themselves, communicating only on one side with the brain, on the other with the different parts. This assertion is true as it respects nutrition, but as it regards the functions it is in part false; for the nerves are evidently only conductors; it is from the brain that goes the impulse, and there too is the sensation. In animals with white blood, and even in those with red and cold blood, these functions concentrated in the brain, in man and the neighbouring species, are, it is true more generally spread throughout the nervous system, hence it is without doubt, that we can remove the brain, the heart and the lungs in reptiles without immediately destroying life; it is on this

account, that I have remarked in my Researches upon Death, that we should never avail ourselves of experiments upon animals with red and cold blood, to draw conclusions concerning those with red and warm blood. But in these and in man especially, it is undeniable, 1st. that the brain is the centre of animal life, which ceases when the action of this viscus is destroyed, as is proved by apoplexy, asphyxia, &c.; 2d. that it has also immediately dependant upon it organic life, though in an indirect way, that is by presiding over the mechanical functions of respiration, which by ceasing, stop the chemical, then the circulation, then the secretions, &c. so that the continuance of the two lives, and a serious injury of the brain, are two things wholly incompatible. Authors who have written upon life, the nervous system, &c. have usually considered them in too general a manner. The relations of the functions are absolutely different in animals with cold blood and in those with warm; that which is true for one, is not so for the other.

Nerves.

Does the nervous coat receive small nervous branches? Do these small branches penetrate the nerves, as the small arteries spread on the coats of the large ones? Anatomical examination does not render this probable.

ARTICLE THIRD.

PROPERTIES OF THE NERVOUS SYSTEM OF ANIMAL LIFE.

I. *Properties of texture.*

Few systems exhibit these properties more obscurely than this. If we draw a nerve, in an opposite direction, in a living animal, it is extended with difficulty, makes

great resistance, and acquires a length but little more than what is natural to it; this appears to depend particularly on the nervous coat. The medullary substance would yield much more. We know how much that of the brain is stretched in the dropsy of the ventricles. If a great trunk is distended by a subjacent tumour, as in popliteal aneurism, by a swelling in the axilla, &c. it is flattened down like a ribbon; its filaments are separated and lay at the side of each other, and it is consequently much widened. Thus distended, these filaments can yet sometimes transmit sensation and motion, at other times these two functions are annihilated there.

In general, a sudden distension interrupts them much more certainly than that which comes on slowly. Hence why the luxation of the head of the humerus often occasions paralysis, whilst it rarely happens from very large chronic tumours in the axilla. Spontaneous luxations of the vertebræ, which always come on slowly, are rarely accompanied by paralysis, an accident which is always the result of those that happen from external violence. It is thus in the brain, osseous tumours, large fungi which increase slowly, disturb its functions but little, while the least depression of a bone of the cranium, that succeeds a fracture, entirely deranges them. In hydrocephalus, also, a great collection of serum has oftentimes but little effect upon sensation, which is nearly destroyed, when a little more of this fluid than common is exhaled in the ventricles, as happens in some kinds of apoplexy.

When a large cavity, like the abdomen, is distended, the nerves that are there yield partly because their curves disappear, and partly because they are really elongated; there is also a greater separation of them.

The contractility of texture is still less evident than the extensibility. A nerve cut transversely, does not retract at the two ends, which remain opposite to each other, like those of a tendon. In amputation, the end of

the nerve remains longer than those of the muscles, the skin, &c. This is sometimes the cause of a painful pressure from some part of the dressing.

II. *Vital properties.*

These are less evident in the nerves, than would be thought at first, from the opinions of a great many physicians, who have made these organs perform almost the whole part in diseases.

Properties of animal life.

The nerves must be considered, in regard to sensibility, in two points of view. 1st. We should examine that which is inherent in them. 2d. It is necessary to consider the part which they take in that of all the other organs.

Animal sensibility inherent in the nerves.

This property is, of all others, the most strongly marked in the nerves. Exposed and irritated, they cause great pain. By tying, pricking, cauterizing, or exciting in any way a nervous filament, we uniformly obtain that result so well known in practical surgery, and by those who make experiments upon living animals.

This property would seem at first to establish a very great difference between the medullary substance of the nerves and that of the brain, especially towards the convexity of this organ; for we can almost with impunity irritate this after having removed the cortical substance. It is only deep in the brain that the animal sensibility becomes strongly marked, and even there it is not so much so as in the nerves. Observe, however, that in the experiments upon the cerebral pulp you destroy the organ itself that perceives, that, without which it could not have animal sensibility, and whose derangement would consequently have an inevitable influence upon this pro-

perty; whereas the seat of perception being untouched when we irritate a nerve, the pain is more sensibly felt. It is, in fact, principally in the medullary substance of each nervous filament, that animal sensibility resides. The nervous coat possesses a much less degree of it. Hence why simple contact, without pressure, occasions but little pain; hence, also, why a nerve can almost with impunity be immersed in a purulent, ichorous fluid, or even in the sanies of cancer; hence why the contact of the air occasions but little pain when the nerves are merely laid bare, as I have had frequent occasion to see in animals; why, in a variety of cases, different tumours, in whose atmosphere the nerves are situated, have no influence upon them. The membrane of each filament is truly in every case a kind of covering that protects its medullary substance, in which the sensibility particularly resides. As to the cellular texture which enters into the composition of nerves, it has, as elsewhere, no connexion with this property. Hence why we can, as I have often done upon a living animal, separate from each other, with the point of a very delicate scalpel, the different filaments of a nerve of some size, of the sciatic, for example, when they have first been laid bare, without giving the animal much pain. In these experiments, it is easy to be convinced of the kind of insensibility of the covering of each nervous filament. It is necessary to pierce it and arrive at the medullary substance in order to produce pain.

In experiments, the animal sensibility of the nerve seems to be gradually exhausted, and finally ceases. I convinced myself of this upon the eighth pair of nerves, in making my experiments upon the injection of black blood into the brain. At the moment the nerve is raised and drawn to detach it from the carotid with which it is connected, the animal cries out and is much agitated; but after the same thing is repeated two or three times, he

no longer gives any signs of pain. If we cease to excite the nerve for an hour or two, the sensibility returns with great energy, when it is drawn again. These experiments furnish a result very analogous to that of experiments relative to the animal contractility of muscles, experiments that are known to all physiologists.

The animal sensibility of the nerves has a peculiar character which distinguishes it from that of all the other systems. It is this character which gives a peculiarity to the pain in these organs, which does not resemble that which has its seat in the skin, in the mucous surfaces, &c. What particularly fixed my attention upon the difference of pain of which each system is the seat, was the question of a man of great mind and coolness, whose thigh was amputated by Desault; he asked me, why the pain he felt when the skin was cut, was wholly different from that which he experienced when the flesh was cut through in which the nerves, scattered here and there, were divided by the knife, and why this last sensation differed entirely from that which was felt when the marrow was divided. This embarrassed me then, when I was wholly engrossed in surgery, and had studied physiology but little; I have seen since, however, that it is to be referred to that general principle of which I have already spoken, and which determines, that as each system has its peculiar kind of animal sensibility in a natural state, it has it also in a morbid state, that is to say, in pain.

A very clear proof of this assertion, as it regards the nerves of animal life, is the peculiar kind of pain that is experienced in the tic douloureux, a kind that is unlike that of any other system. The sciatic disease, which has its seat in the nerve of the same name, has often been confounded with rheumatism, which affects the muscles or tendinous parts; but the difference of pain alone is sufficient to distinguish them. Mr. Chaussier has very judiciously taken for the first character of neuralgia, the

nature of the pain. Every one knows the peculiar sensation of numbness and afterwards of pricking, that is felt when a superficial nerve, as the cubital, &c. is compressed. No other organ in the economy gives the same sensation from the same cause.

The animal sensibility of the nerves has another peculiar character, which consists in this, that the local irritation of a trunk often produces suffering in the whole branches. 1st. We know that when the cubital is compressed at the elbow, the pain extends along its whole course, and that it spreads over the whole external part of the leg, when the peroneal suffers. 2d. In the tic doulоureux of the face, in the sciatic disease, and generally in all that class of diseases of which Mr. Chaussier has given a sketch under the name of neuralgia, an analogous observation may be made. 3d. When we wound, without dividing, one of the branches of the saphena, the internal cutaneous or muscular cutaneous, in the operation of blood-letting, the subjacent part frequently becomes numb, then painful and swelled; the irritated point is a centre, whence go forth, along the whole course of the nerves, painful irradiations, the consequences of which oftentimes cannot wholly be stopped, except by dividing the irritated trunk. Thus, in tic douloureux, the division of the nerves has sometimes overcome the disease, though we shall succeed less frequently here by these means than in the preceding case, where the affection is local, while here it is usually extended along the whole course of the nerve. 4th. I have irritated, in a dog, the sciatic nerve with nitric acid; the whole limb was swelled and painful the next day. I have at this time another, the whole of whose fore limb is swelled, because I passed a pin, two days before, through one of the anterior nerves, taking care to entangle some of the nervous filaments. This precaution is essential, for I passed a pin through the cellular texture that sepa-

rates the filaments of the sciatic, without producing any effect. I should observe, however, that these different experiments do not always succeed, and that I have irritated a nerve at one point sometimes without producing any effect. 5th. The ligature of nerves is rarely followed by these accidents, because the communication with the brain is interrupted, by the very means that irritate, and because the medullary substance is flattened and its sensibility destroyed. However accidents have often happened from tying a nerve in the operation for aneurism, and though there is no real danger in making the ligature, all good practitioners advise that it should be avoided.

These different considerations prove in a positive manner, the influence that a portion of an irritated nerve has upon the animal sensibility of all the subjacent ramifications. Physicians do not give sufficient attention to this cause of pain, which is often very extensive without any apparent wound. An irritated nerve in a fracture of the ribs, in that of a limb, in a wound, in a tumour, &c. can produce at a distance a number of phenomena, the cause of which often escapes us, and which we should soon discover if we reflected upon the distribution of the branches going from the trunk of the nerve that is near the affected part.

Why in these phenomena, is the animal sensibility of the nerve below the affected part always raised? Why does this phenomenon never take place on the side of the brain, though it is in this direction that sensation is conveyed in a natural state? I know not.

No other system, among those all of whose parts are united like the nervous system, presents the same phenomenon. The arterial, the venous, the absorbent, never feel thus in their different ramifications, the affections of any one part of their trunk. The cellular is not affected at a distance by the diseases of one of its parts. In the

mucous which is continuous, a part being irritated, oftentimes others also are affected, as when the stone in the bladder produces suffering in the glans penis; but there is always an intermediate portion more or less considerable, which remains without being painful; this is a real sympathy; whereas in the other, the whole nervous trunk suffers, from the affected part to the nervous extremities.

Influence of the nerves upon the animal sensibility of all the organs.

After having considered the animal sensibility in the nervous system itself, we must examine the part this system performs in this property described in relation to all the other organs, in which it is often the means of transmission between the organ that receives the sensation and the brain which perceives it. So that when any point of the nervous system suffers, as in the preceding cases, the portion of nerve that is between this point and the brain, serves to conduct the impression. Thus in animal contractility, the nerves are always intermediate to the brain, which is the principle of the motion, and to the muscle that executes the motion. There is, however, more difficulty in the first kind of transmission than in this, which, to be explained accurately, requires that we should distinguish two kinds of sensations perceived by the internal sensitive principle, 1st. the external; 2d. the internal.

The external sensations are of two orders, 1st. the general; 2d. the particular. The general sensations are derived from the sense of feeling, as we shall see; they indicate the presence of the bodies that are in contact with the external organs; they give the general impressions of heat and cold, moisture and dryness, hardness and softness, &c.; they produce a painful sensation when the external organs are torn, pricked, or acted upon by chemical agents, &c. These sensations may originate

upon the skin, the eye, the ear, the mouth, the nostrils, upon the beginning of all the mucous surfaces, &c.; all the bodies in nature may produce them, and all the external organs may perceive them. 2d. The particular sensations are relative to certain determinate external bodies, or to particular emanations from surrounding bodies. Thus the eye exclusively perceives the light, the nose odours, the ear sounds, the tongue tastes, &c. These particular sensations are to a certain degree independent of the general ones; thus the eye may cease to see, the nose to smell, the ear to hear, the tongue to taste, and yet these different organs may preserve the faculty of perceiving the general attributes of heat and cold, moisture and dryness, &c. and may be the seat of real pain. Every day we see patients affected with gutta serena suffering from the eye, those affected with deafness having pains in the ear, &c. I have seen a man that was deprived of the sense of smell from the use of mercury, and who still would suffer very much if the pituitary membrane was irritated, &c. It is necessary, then, to distinguish in the organs of sense, that which belongs to the general sense of feeling, from that which is dependant upon the particular kind of feeling that each has separately.

If now we examine the part of the cerebral nerves in these two kinds of animal sensibility, it appears that they are equally essential to one and the other. 1st. This is without doubt as it regards the organs of sense; the sight, the hearing, the smell, or the taste, could never continue after a serious injury of the optic, auditory, olfactory, gustatory nerves, &c. I do not speak of the touch, which does not require, like the other senses, a peculiar modification of animal sensibility, but only the general feeling, with a peculiar form in the organs that are provided with it, so as to mould themselves to the figure of external bodies. 2d. As to the general sensa-

tions, whenever the cutaneous nerves cease entirely to act in any part of the skin, it becomes absolutely insensible; it may be pinched, irritated, burnt, &c. without feeling it. The perfect paralyses of sensation exhibit in man this phenomenon, which can easily be produced in animals by cutting or tying all the nerves that go to a limb. When the general feeling is left in the pituitary membrane after the loss of smell, the olfactory nerve is alone paralyzed; if the nerves that enter by the spheno-palatine foramen, through the anterior and posterior openings of the nostrils, cease also to act, then the general feeling is likewise lost. It is the same with regard to the other organs of sense.

I believe, then, that the nerves are actually necessary to the external sensations, whatever be their nature. Observe also, that all the organs with which external bodies can be in contact, as the dermoid system, all the origins of the mucous systems, and the organs of sense, are provided more or less abundantly with cerebral nerves; none of them receive the nerves of the ganglions. This external portion of the nervous system of animal life is very considerable; united to the portion that goes to the voluntary muscles, it forms almost the whole of this system, which has but very few appendices in the organs of internal life.

As to the internal sensations, they have phenomena much more obscure than the preceding. The brain is undoubtedly the centre of these sensations, as well as those which take place without it; in fact, if the action of this organ is suspended by wine, opium, or any other means, though acute pains may affect the internal organs, these pains are not perceived. Thus when the brain has received a concussion, though the impression of sounds, of light, of odours is made as usual upon the ear, the eye and the nostrils which are uninjured, yet there is neither hearing, seeing or smelling. But how do the impressions

made upon the internal organs get to the brain? Here are different phenomena, that it is impossible to conceive of well, by supposing that the nerves are charged with transmitting these impressions exactly like those which are experienced by the external organs.

1st. There are organs that have the most acute sensibility upon the slightest touch, and which however receive very few apparent nerves; such is the medullary membrane of the long bones. 2d. Certain organs in which the cerebral nerves evidently enter, as the liver, the lungs, &c. can be irritated in animals, without seeming to give them much pain. 3d. The muscles of animal life, in the structure of which so many nerves enter, in which also the branches of these perform so great a part as it relates to animal contractility, do not occasion much pain when their texture is cut without entangling the nervous filaments that penetrate them. 4th. The ligaments, that no nerve enters, are the seat of acute pain when they are distended, as my experiments have proved. It is the same as it respects the tendons, the aponeuroses, &c. 5th. All the organs with the structure of which the nervous system has manifestly no connexion, transmit however to the brain the most painful impressions when they are inflamed, &c. &c.

I could bring many other facts, which the opponents of Haller have carefully collected; but these are such, that we cannot hesitate to admit, that the opinion of this celebrated physiologist should not be entirely acceded to.

All that we know upon the internal sensations is, that, 1st. there is an organ in which the cause of sensation is seated; 2d. that this organ transmits to the brain the particular modifications that it experiences in its vital forces. But we are wholly ignorant of the medium of communication of one with the other. Hence, why, in my division of the vital forces, I have avoided a systematic basis. The distinction of the two kinds of sensibility, of the three

kinds of contractility, rests wholly upon the observation of facts. Such is the obscurity of the phenomena of life, that I doubt if we shall ever be able to establish divisions from a knowledge of the nature and essence of the vital forces.

I observe that there is a great difference between animal sensibility and contractility; that in the first, the nerves are in certain cases the evident agents of communication between the organs that receive the impression and the brain that perceives it, but that in other cases, we know not the kind of relation; whilst in the second, it is always manifestly by the nerves that the brain communicates with the muscles, and that the organs can never execute a voluntary motion without the influence of the cerebral nerves.

Let us confine ourselves to this general view, which is from accurate observation; let us abandon reasoning, where experiments are not the basis of it. Some modern authors have been less judicious; they have admitted a nervous atmosphere extending more or less remotely, and acting at a determinate distance; so that though an organ may not receive a nerve, it is sufficient that it should be in the atmosphere of a nervous cord to be the seat of sensations. This ingenious idea of Reil, should be placed at the side of a great number of those that Bordeu has scattered in his works, and which are rather proofs of an ingenious author, than an accurate and judicious mind, hostile to every opinion not founded on rigorous experiment. In fact, what is this atmosphere? Is it an emanation that is constantly made at the exterior of the nerves? Is it a fluid that is independent of them, and that nature has placed around each nervous cord, as it has placed the air around the earth? Is it a power that has been given to the nerves to act at a distance without intermediate bodies? Some galvanic experiments seem to prove something similar to this in the nerves; but these experiments have no relation to the

transmission of animal sensibility. Moreover, when pain takes place in the middle of a very thick tendon, in the centre of a large articulation, as that of the knee for example, it would be necessary that the atmosphere of nervous activity should extend sometimes even an inch. Why is there not suffering produced, by the irritation of an insensible part that is at the side of a nerve, or even connected with it, whilst the pain is very acute in an inflamed part, though it is at a distance from every nervous cord? Would the nerves then have also, a sphere of activity for motion? But why should the contiguity of the nerve never be sufficient to produce it in the muscles? Why is it not the same of sensation?

Animal contractility. Influence of the nerves upon that of the other parts.

The texture of the nerves is wholly destitute of this contractility. No kind of sensible motion is ever observed in them; they perform however an essential part in this property, considered in relation to the muscles of animal life. We shall see that they are the essential agents which transmit to them the principle of motion; so that animal contractility always supposes the exercise of three successive actions, viz. that of the brain, the nerves and the muscles.

The opinions of physiologists have been singularly divided upon the manner in which the nervous influence is propagated. Some have admitted a kind of vibration, others a fluid pervading the insensible canals of these organs. This last hypothesis is still in much credit. What has not been said upon the albuminous, electric, magnetic nature, &c. of this fluid? The article upon the nerves, in most physiological treatises, is almost wholly devoted to the examination of this question, but I shall say nothing upon it, for we do not know any thing that rests upon experiment. Moreover, are we not able

without knowing the mode of the nervous action, to study and analyze the phenomena of the nerves? It is the common fault of all the ancient physiologists, to have wished to begin where they should one day end. Science was in its infancy when all the questions they discussed turned upon the first causes of the vital phenomena. What is the result of it? an immense deal of rubbish, and the necessity of finally coming to the accurate study of these phenomena by abandoning that of their causes, until we have observed enough to establish theories. Thus mankind have disputed for ages, upon the nature of fire, of light, of heat, of cold, &c. until philosophers finally perceived that before reasoning it was necessary to have a foundation upon which their reasoning should rest, they then sought for these foundations and thus created experimental philosophy. Thus interminable disputes have existed in the schools upon the nature of the soul, of judgment, &c. until metaphysicians have perceived the necessity of analyzing the operations of our intellectual faculties before they can know their essence. Each of the natural sciences has almost had two epochs; 1st. that of the last age, in which first causes were the only subject of discussion; an epoch useless to the sciences; 2d. that in which they have begun to be composed of the study of the phenomena only that experience and observation offer. Physiology has still one foot in the first epoch, whilst it has placed the other in the second. Physiologists of the present day should advance it still further.

Properties of organic life, considered in the nerves.

They are in general very indistinctly marked in these organs. They want sensible organic contractility. The insensible and the organic sensibility are there only to that degree that is necessary to nutrition; for these properties have no other functions to support there. Thus observe, that almost all the diseases of the nervous system

are affections of the animal sensibility, and that but very few suppose a disorder in the organic. There is hardly ever an alteration in the nervous texture; no tumours, fungi, ulcerations, &c. as in the systems in which the organic properties are predominant. Thus morbid anatomy finds but little to exercise itself upon in the nerves.

The continual motion of a part sometimes increases a little the organic sensibility of the nerves that are found there, makes their nutrition more active and their size more apparent; but generally this phenomenon is infinitely less sensible in them than in the muscles. On the other hand though the nerves may have lost the faculty of transmitting sensation and motion, this last especially, they still preserve for a long time the same degree of organic sensibility, and their nutrition is the same as usual. I have many times examined comparatively the nerves of the sound side and those of the side affected with hemiplegia; I have never found in them any difference. It is only when the limb becomes atrophous, which never happens except at the end of a long time. that the nerve diminishes in size.

I have often searched to see, if, when a part, in which there are nerves, has been a long time the seat of uninterrupted painful sensations, the nutrition of these is altered, and consequently if their organic sensibility is affected. I have dissected the stomachic cords in cancers of the pylorus, the uterine nerves in those of the womb; I have not found any sensible difference, except in two subjects, in whom they were a little enlarged. Desault discovered also in a body affected with carcinoma of the fingers, the median nerve of uncommon size; but this phenomenon certainly is not as general, as the dilatation of the arteries in this kind of tumours. As to acute pains, like those of rheumatism, of different inflammations, &c. however severe they may be, they have no effect upon the nutrition of the nerves which transmit them. When the pain

is seated even in the nervous texture itself, as in the tic douloreux, there is oftentimes no organic affection. At least Desault had occasion to open two patients that had had that disease, and the nerves were the same on each side. This, however, deserves further research, and it may be, that in many cases, the internal substance of the nervous cords is a little altered; for I preserved the sciatic nerve of a patient, who had experienced very acute pain in its whole course, and this had at its superior part, a number of little varicose dilatations of veins that entered it.

Influence of the cerebral nerves upon the organic properties of other parts.

Have the cerebral nerves any influence upon the organic sensibility of other parts? I think not, and this is the essential difference that distinguishes it from animal sensibility, which we can with difficulty conceive of, especially in its natural state and in the external sensations, without the nervous influence intermediate between the brain and the part that receives the impression. To prove this assertion, let us examine the functions that depend upon organic sensibility. These are, 1st, the capillary circulation, 2d, secretion, 3d, exhalation, 4th, absorption, 5th, nutrition. In all the phenomena of these functions, the fluids make an impression on the solids of which we have no consciousness, and in consequence of which the solids react. It is by the organic sensibility that the solid receives the impression, it is by the insensible contractility that it reacts; now in none of these cases do the nerves appear to perform an essential part.

1st. The capillary circulation exists in the cartilages, the tendons, the ligaments, &c. in which the nerves of animal life do not enter. Inflammation, which is only a derangement, an increase of this capillary circulation, takes place in these organs, as well as in those that are

the most nervous; what do I say? where the nerves are the most numerous, this affection is not the most frequent; the muscles are an example of this. The tongue, whose surface alone has more than four or even five times the quantity of nerves of the mucous surface, is not so often inflamed as the rest of this system. The retina, which is entirely nervous, is rarely inflamed. Nothing is more rare as I have said, than the inflammation of the nerves themselves; the internal substance of the brain is hardly ever inflamed. On the other hand, examine the serous surfaces, the cellular texture, in which there are infinitely less nerves; the capillary circulation is constantly active there, and inflammation comes on. In the limbs of paralytic patients, in animals in whom the nerves are cut in order to render a part insensible, does not the capillary circulation continue as usual, when the nervous action has ceased there? Have you ever accelerated this circulation in a limb, or produced inflammation, by increasing convulsively by irritation the action of the nerves of this limb? The phenomena of convulsions and those of paralysis, are wholly distinct and have no analogy with those of inflammation; this would not be so, however, if the cerebral nerves had any influence upon them. In the first phenomena, it is the animal sensibility that is altered; in the second it is the organic; this is then independent of the cerebral nerves.

2d. Exhalation is the second function over which this last property presides. I refer to the dermoid system to prove that the sweat is independent of the nerves. I would only observe here, that in the synovial, in which there is an evident exhalation, there are hardly any nerves; that the serous surfaces and the cellular texture, so remarkable for this function, are, as I have said, almost destitute of them; that whenever there are accidental exhalations, as in cysts, hydatids, &c. the nerves have evidently no influence, as the tumour is uniformly

without them; that by acting in any manner upon the nervous system, as by irritating the nerves, the brain, or the spinal marrow, in order to excite this system, as by tying or cutting the first, and compressing the second, to annihilate or weaken its action, the cellular, serous, synovial, or cutaneous exhalations are never in any way affected; and that finally the diseases of the nervous system have no other influence upon this function, than what is derived from general sympathy.

3d. As much may be said of absorption. It is during sleep that the skin oftentimes absorbs most easily; now there is at that time, an intermission in the action of the nervous system, as well as of that of the brain. This intermission, to which it is periodically subject, ought to produce one in the serous, synovial, medullary absorptions, &c.; but yet they go on constantly. It is the same of all the functions over which the organic sensibility presides; they are essentially uninterrupted, though the nervous and cerebral actions are essentially intermittent.

4th. The same observation may be made concerning the secretions, notwithstanding what Bordeu may have said. For the rest, I refer upon this point to the glandular system.

5th. Nutrition takes place in parts that evidently receive no nerves, as in the cartilages, the tendons, &c.; in paralyzed limbs also its alterations are always independent of those of the nervous system. Those people in whom this system is the most elevated, who are the most sensitive, are not those in whom nutrition is the most active. In no experiment, I believe, has any one been able to influence nutrition by acting upon the brain, the nerves, and the spinal marrow. Marasmus undoubtedly succeeds all prolonged nervous diseases; but it is a phenomenon common to many diseases. In palsy, the long rest, as well as the deficiency in the action of the nerves, has an influence in producing atrophy; but it

is a long time before this manifests itself. Who does not know that often at the end of two, three, or four years even, the diseased limb is exactly of the size of the well one? Moreover, natural nutrition obeys the same laws as accidental nutrition, as that which takes place in the formation of fungous and sarcomatous tumours, and fleshy granulations. Now the cerebral nerves have evidently no connexion with all these productions; they are never found in them; a phenomenon very different from that which is offered by the arterial system, which is almost always developed in a remarkable manner in these tumours. In fine, we shall see hereafter that the nerves do not increase in proportion with the parts to which they are distributed.

From what has been said, it is evident that all the phenomena, over which preside what are commonly called the tonic forces, viz. organic sensibility and insensible contractility, are completely independent of nervous action; and consequently that these properties would not, like those of animal life, require this action. Each kind of sensibility has its morbid phenomena over which it presides. Inflammations, suppurations, the formation of tumours, dropsies, sweating, hemorrhages, disorders of secretions, &c. &c. belong to the alterations of the organic sensibility, whilst every thing like spasm, convulsion, paralysis, trance, torpor, injury of the intellectual functions, &c. &c. every thing, in fact, which tends in diseases to destroy our relations with surrounding bodies, belongs to the alterations of animal sensibility or contractility, and implies a greater or less degree of disorder in the nervous system.

In general, the diseases that affect the functions of animal life are of a nature wholly different from those which destroy the harmony of organic life. They have not the same character, the same progress, and the same phenomena. Place on one side the injuries of the external

senses, blindness, deafness, loss of taste, &c.; those of the internal senses, mania, epilepsy, apoplexy, catalepsy, &c.; those of the voluntary motions, &c.; on the other, fevers, hemorrhages, catarrhs, &c. and all the diseases that disturb digestion, circulation, respiration, secretion, exhalation, absorption, nutrition, &c.; we shall then see what an immense difference there is between them.

Physicians have used too vaguely the term nervous influence. If in medicine, as in physiology, we had accustomed ourselves to use those expressions only to which was attached a precise and definite meaning, this would have been employed much less frequently.

It appears that the nerves have some influence still unknown, in the production of animal heat. The following facts relate to this influence. 1st. In aneurism, the ligature of the nerve is often followed by a sensation of general torpor and coldness in the limb. 2d. Sometimes, in hemiplegia, the affected part is of a temperature below what is natural, though the pulse may be as strong in this side as the other. 3d. One of the characters of ataxic fevers, the principal seat of which is in the brain, is the remarkable irregularity in the temperature of the different parts of the body. 4th. Animals, with a strongly marked nervous system, as quadrupeds and birds, are those of all others, in whom the degree of natural heat is the highest. 5th. I knew a person that had had the cubital nerve divided by a piece of glass above the pisiform bone, and whose little and ring fingers of that hand uniformly remained colder than the rest. 6th. Often in luxations, the compression of the nerves by the heads of the bones, produces an analogous effect, &c. &c.

However, the heat is not always increased, when the nervous action is augmented, nor is it always lessened when this action diminishes; there are as many cases in which the heat appears to be independent of the nervous system, as there are where it appears to be connected

with it; so that we are still confined here to the collection of facts, without drawing general conclusions from them.

Sympathies.

I divide what I have to say upon the sympathies of the nerves, as I did that which was said upon their vital forces; that is to say, I shall examine first the relations that each nerve has with the other parts, then I shall speak of the general influence that the nervous system exercises upon the sympathies and of the part it takes in them.

Sympathies peculiar to the nerves.

There is no doubt as to the relations of the nervous with the other systems, of those which it has with the muscles and with the brain. In fact, these relations are natural; for the one cannot be affected without the other's feeling it. These three organs can in this respect be considered under one point of view. Thus too, the pulsation of the arteries is always connected with the action of the heart, &c. Every idea of sympathy excludes that of a natural connexion of functions. Barthez is mistaken upon this point. I speak only of the unnatural relations of the phenomena that take place between an organ and a portion of the nervous system which is not connected with it by the natural order of life; now, thus considered, the nervous sympathies are very numerous.

1st. Two nerves of the same pair often sympathize with each other. We know in medicine the relation there is between the two optic nerves; the one being disordered in its functions, the other frequently becomes so. This happens more rarely with regard to the ears, the nostrils, &c. though it sometimes takes place in them. Often in neuralgia (a word which I adopt very willingly and which is wanted in the science to express a class of diseases every genus of which has a distinct name) often I

say in neuralgia a nerve being painful, the corresponding one becomes so sympathetically. I have an example of this at present; it is a woman, who for two months has been afflicted with sciatica of the left limb. In changes of weather, a pain precisely similar spreads itself along the course of the nerve of the opposite side. I applied two blisters upon the thigh first affected; the pain disappeared in both sides at the same time at the end of twelve hours. Thus, in order to cure pains in both eyes, it is oftentimes sufficient to act only upon one, &c.

2d. Sometimes two nerves of the same side sympathize without belonging to the same trunk. Thus an injury of the frontal nerve has been many times followed by a sudden blindness in consequence of the affection of the optic nerve, &c.

3d. In other cases it is the branches of a common trunk which influence each other reciprocally, as when a branch of the superficial temporal is wounded in the operation of arteriotomy, the whole face, which also receives its nerves from the fifth pair, becomes painful, &c.

4th. At other times, it is not among themselves that the nerves sympathize, but with other organs; and then sometimes they influence, at others they are influenced.

I say first they influence; thus a nerve being irritated in any way, a number of sympathetic phenomena take place in the system. Diseases frequently show these facts. It is thus in tic douloureux and analogous diseases, in which the nervous texture is particularly affected, sometimes the animal sensibility is raised in various remote parts, and hence the pains that are often experienced in the head, in the internal viscera, pains that cease when the cause that supported them has disappeared. Sometimes it is the animal contractility; hence the convulsions that occasionally take place in the muscles that receive branches from the affected nerve. In some cases it is the sensible organic contractility which is sympa-

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thetically excited by the nervous affections. Thus in the paroxysm of neuralgic pains there is often spasmodic vomiting, the action of the heart is hurried, &c. We can by experiments produce the same phenomena. Thus by acting upon the nerves of the superior or inferior extremities, by irritating them any way after they have been laid bare, I have frequently produced vomiting, or convulsions in muscles that were in no way connected with the nerves I irritated.

In the second place, the nerves can be influenced by diseased organs; thus in many acute and chronic affections, sympathetic pains spread along the course of different nerves, particularly in the extremities. As the animal sensibility is the predominant property of the nerves, it is almost always that which is brought sympathetically into action. Physicians have not distinguished with sufficient accuracy in the pains of the extremities, that which belongs to the nerves, from that which has its seat in the muscles, the aponeuroses, the tendons, &c.

Influence of the nerves upon the sympathies of the other organs.

Authors have been much divided upon the cause that supports sympathies. How can an organ which has no relation with another that is frequently very remote, influence it so as to produce serious diseases there, merely because it is itself affected? This singular phenomenon is often witnessed in a state of health; but it is so wonderfully increased in diseases, that if we could remove from them the symptoms that are not exclusively dependant upon the derangement of the function particularly affected, we should find but little difficulty in their study or treatment. The moment an organ is affected, all the rest seem to feel simultaneously the disorder it experiences, and each seems to be agitated in its own way in order to expel the morbific matter that has seized upon one of them.

Most authors have believed that the nerves were the general means of communication that connected the organs with each other, and also their derangements. The anastomoses have appeared to them to be destined to this use; and with this opinion, some have thought that the brain was always mediately affected, but this others have rejected. The communication of parts by the means of blood vessels has also been thought to be a cause of sympathies. Others have admitted the continuity of the cellular texture; some, that of the mucous membranes. I shall not undertake to refute in detail these different hypotheses; I would observe only, that as no one is applicable to all the cases of sympathy, it is because the aberrations of the vital forces have been described in too general a manner; it has been thought that a single principle presided over them, and this principle has been sought for. But in order to ascertain the cause that supports sympathies, they must be divided, as I have divided the vital properties; for as each of these properties supposes different phenomena, so the sympathies that put them in action, differ also. To make this distinction of the sympathies more evident, let us suppose a diseased organ, the stomach for example; it becomes then a centre, whence go forth numerous sympathetic irradiations, which bring into action in the other parts, sometimes the animal sensibility, as when pains of the head come on; sometimes contractility of the same species, which is the case when worms in the stomach produce convulsions in children; sometimes, sensible organic contractility, which, raised in the heart by certain pains in the stomach, occasions fever; oftentimes the insensible organic contractility and the organic sensibility, as when the gastric affections increase sympathetically the secretions that take place upon the tongue, and produce there a mucous coat. There are then sympathies of animal sensibility and contractility, and of organic sensibility and con-

tractility. This being premised, let us examine the cause of each.

1st. When the animal sensibility is sympathetically raised in a part, this does not always depend on nervous communications; for oftentimes the organ in which is the material cause of pain does not receive any nerves, as the tendons, the cartilages, &c.; then it cannot communicate by them with that in which this pain is found. On the other hand we have seen above that it is still very uncertain if the nerves are the only agents that carry to the brain the internal sensations; we cannot say then that the affected organ acts at first upon the brain by their means, and that this reacts afterwards upon the part in which the pain is seated, by the nerves that go to it. Can we conceive that the cellular texture should be an agent for the communication of pain, which is insensible to it itself? Observe also that the parts that are the most abundantly supplied with this texture, as the scrotum, the mediastinum, &c. are not those that sympathize the most. The same is true of the blood vessels, which, by their nature, are not fitted to transmit animal sensibility, and which besides do not exist in all the organs.

It appears that all sympathetic pains are nothing but an aberration of the internal sensitive principle, which refers to a part a sensation, the cause of which exists in another. Thus when the extremity of the stump gives the patient pain, who has just undergone amputation, the sensitive principle perceives the sensation correctly, though it is deceived as to the place whence it comes; it refers it to the foot which no longer exists. It is the same when a stone irritating the bladder, produces pain at the glans penis. Thus all sympathy of animal sensibility is characterized by the integrity of the part in which we find the pain, and by the cessation of this sympathetic pain, when the cause that acts elsewhere has ceased. It is then probable, when a part suffers sympathetically, that that which

is the seat of the material cause of the pain acts first upon the brain, either by the nerves, or by some means with which we are unacquainted, and that when the brain perceives the sensation, it is mistaken as to it, and refers it to a part from which it does not arise; or it refers it at the same time to the part from which it arises, and to another where it does not; this happens frequently. The stone for example, produces suffering at the same time in the bladder and at the end of the glans penis.

These aberrations of animal sensibility then exist entirely in the brain; it is an irregularity, a derangement of perception; this irregularity presents phenomena analogous to the following; we often refer to the skin a sensation of heat, as we shall see, though caloric is not disengaged there in a greater quantity than usual. We know that oftentimes the sensations of hunger and that of thirst are purely sympathetic, and that the cause which produces them in a natural state does not then exist in the stomach or intestines. We know the illusions of vision, of hearing, of the smell even, &c. We have not studied sufficiently the irregularities of perception; those of the memory, the imagination, the judgment, &c. have been analysed. These, however, have been almost forgotten. They perform the greatest part in animal sensibility.

2d. Animal contractility supposes constantly nervous action, when it is put in exercise sympathetically. In fact we shall see that this property cannot be exerted without the triple action of the brain, of the nerves that go to the muscles that move, and of the muscles themselves. When a muscle of animal life is brought into action by the irritation of any distant organ, by the distension of the ligaments of the foot for example, this organ acts at first upon the brain, which then reacts by means of the nerves upon the voluntary muscles that are concerned in convulsions. The following is an experiment by which I satisfied myself of the cerebral and nervous influence in

the sympathies that occupy us. I cut all the nerves of the inferior limb of one side, in different animals, and I afterwards irritated in a thousand different ways, very irritable parts, as the retina, the pituitary membrane, the marrow of the bones, &c. I produced in this way a number of sympathetic phenomena, sometimes of organic contractility, as vomiting, involuntary evacuations of urine, fecal matter, &c. sometimes of animal contractility in the muscles whose nerves remained untouched. But the muscles whose nerves were cut, were never brought into action. I have very frequently repeated these experiments, which would have certainly produced results, if the nervous communications could, without the intervention of the brain, make the muscles of animal life contract. I would observe upon this subject, that sufficient regard has not been paid in experiments upon sensibility, to the sympathetic phenomena. I do not know even that these phenomena have been the object of any experiments upon animals, before those of which I have here given the first results, and which I propose to multiply under other points of view. There are then two things in all sympathy of animal contractility, viz. 1st, the action upon the brain of the organ that suffers, by means, of which as yet we know but little; 2d, reaction of the brain upon the voluntary muscles. In this last period of sympathy, the nerves of animal life are the agents constantly necessary.

3d. The cerebral nerves and brain, have evidently no connexion with the sympathies that put in action sensible organic contractility or irritability. If they had, the affected organ would first act upon the brain, and this would react upon the involuntary muscle; thus, when tickling produces vomiting, there would be an action of the skin upon the brain, and of the brain upon the stomach. Now the brain never exerts any influence upon the involuntary muscles; whatever be the irritation that the nerves ex-

perience which go to them, the muscles remain unaffected. Then although the brain may be sympathetically affected, it does not react upon the involuntary muscles; the cerebral nerves then have no connexion with the sympathies of sensible organic contractility. The continuity of the membranes is not a more substantial cause, and this is the proof of it. We know that by irritating the uvula, the stomach heaves; now as the mucous surface of the one and the other is the same, we might attribute this sympathetic phenomenon to this circumstance. I have then made a wound in the side of the neck of a dog; taken hold of the œsophagus and cut it transversely; the uvula has been afterwards irritated; the dog, notwithstanding the interruption of continuity, made efforts to vomit as before. Let us acknowledge then that we do not know the cause of the sympathies of sensible organic contractility.

4th. As much may be said of the sympathies of organic sensibility and insensible contractility. We have proved that the nerves have no influence upon these two properties; that by acting upon them we neither increase or diminish them in any manner, and that their diseases do not disturb the functions over which these properties preside. Then when they are sympathetically disordered, the nerves appear to have no connexion with these phenomena. Thus, 1st, every sympathetic exhalation, as the sweats of phthisical patients, certain serous infiltrations that take place almost instantaneously, &c.; 2d, all secretions of the same kind, as those which appear in a number of diseases afford us examples of them, &c. 3d, all analogous absorption, the three functions over which the preceding properties preside, are evidently unconnected with the nervous influence of animal life. I shall say the same of the cellular, vascular influences, &c. Certainly we have no data, by which we can explain how these means of communication produce sweat when

the lungs are affected, and saliva in the mouth when the membrane of the palate is irritated, &c.

From all that has been said it follows, 1st. that the sympathies of animal sensibility appear to be in the greatest number of cases an aberration of the principle that perceives in us, and which is deceived as to the place in which the causes of sensation act; 2d. that the sympathies of animal contractility require inevitably the intervention of the brain, but we know not how the part affected acts upon this viscus, though we know very well how this viscus sympathetically excited reacts upon the muscles to make them contract; 3d. that the causes of the two kinds of organic sympathies are absolutely unknown and that a thick veil hides the agents of communication which connects, in this case, the organ from which the sympathetic influence goes to that which receives it.

It is this obscurity of the sympathetic causes, that has made me entirely neglect every kind of hypothetical opinion, in classing the sympathies in this work, in which I examine them in each system of organs. I have had regard only to a natural division, to that indicated by the vital forces of which the sympathies are but an irregular exercise. Now by limiting ourselves to the most rigorous observation, it is evident that this division is the only one that is admissible; and I believe that there is no other to be employed, until our knowledge shall be sufficiently extended to admit of their being classed by the causes that produce them, and not by the results they present.

Besides I cannot recommend too strongly the necessity of distinguishing what belongs to them from that which arises from the natural connexion of functions. Observe what takes place in syncope, apoplexy and asphyxia; one organ is disordered; all the others soon cease to act. Sympathies have no part in these phenomena. Physicians have been much embarrassed by classing these

affections, sometimes as if they belonged to the nerves, at others to the sanguineous system, &c. This is what takes place in each.

1st. The heart first ceases to act in all syncopes, whether they arise from passions of the mind, disagreeable odours, &c. The circulation being stopt, the brain is no longer excited by the blood; it ceases its action, and the whole of the animal life is interrupted. The organic life that the blood supports, is thus suddenly annihilated. 2d. Asphyxia commences in the lungs. Respiration is deranged; it sends to the brain blood that cannot excite it; this ceases to correspond with the senses, to determine involuntary motions, &c. &c. 3d. It is in the brain that apoplexy has its first seat; thus animal life is immediately interrupted; then, when it is very severe, the brain not being able longer to support the motions of the intercostal muscles, these motions are stopt; the mechanical, then the chemical action of the lungs ceases; circulation cannot go on, and organic life is interrupted. We see then, that in all the phenomena of these affections, the injury of one organ, produces, by a natural consequence, the suspension of the action of the others.

This is wholly different in the sympathies. Thus the functions of the skin being suspended, sometimes the lungs, sometimes the stomach, and sometimes the intestines, feel it and are affected by it; these sympathetic phenomena may manifest themselves or may not; on the contrary, whether it be the cerebral, pulmonary or cardiac action, that is deranged, it is impossible but that the others should be consequently affected.

III. *Properties of reproduction.*

Are the nerves reproduced when they have been cut? The experiments of many distinguished anatomists evidently prove that they are. What is the manner of this reproduction? If we examine the results of these experi-

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ments it is easy to see that there is nothing peculiar in the nervous system, that it is a simple cicatrization analogous to the callus of bones, to the cicatrix of the skin, &c. When a nerve has been cut, its two ends inflame, the cellular texture that it contains sends forth granulations by the property of reproduction that it possesses. These granulations meeting, form adhesions that unite the two divided ends of the nerve. As the cellular texture, the means of union, grows from the cut extremity of the nervous coat, as well as from that which is between the cords, it partakes of the nature of the nervous coat, and becomes a parenchyma of nutrition, whose mode of organic sensibility is analogous to that of the nerves, and whose vessels deposit there medullary substance, which gives a new appearance to the nervous cicatrix, and makes it resemble very nearly the texture of the nerves themselves. However, as the granulations arising from the divided ends are not made in a regular manner, there is never at the place of union a thread-like arrangement as there is in the nerve itself. Thus the callus of a long bone, though analogous to this bone, is never regularly arranged like it in longitudinal fibres; thus a cutaneous cicatrix has always an irregularity in its organization, which arises from the irregular manner in which the parenchyma of cicatrization has been developed.

The cicatrization of nerves is then analogous to that of bones. In the first period there is inflammation; in the second, growth of the cellular texture which is to serve for the nutritive parenchyma; in the third, adhesion of those parts that have grown; in the fourth, exhalation of the medullary substance into the parenchyma. It is this medullary substance that makes this cicatrix differ from the osseous, in which phosphate of lime and gelatine are deposited, from the muscular, in which there is fibrin, &c. Sometimes there is an enlargement in the form of a ganglion, at the place of the reunion of the nerves;

this depends upon the greater granulation of the cellular texture. Thus sometimes the callus is enlarged; at others, if the contact has been exact, we perceive but a slight difference; these are varieties that do not affect the nature of cicatrization.

It follows from this, that the regeneration of the nerves, which has lately been the object of much research, and which Cruikshank, Monro, &c. have particularly demonstrated, has nothing peculiar in it; that it is only a consequence of the general laws of cicatrization, and a proof of the constant uniformity of the operations of nature, though these operations present at first sight different results. A nerve, that is cut out in its whole course, is never reproduced like a nail, or the hair, which take a length, form, and appearance exactly the same as they had before they were removed. It is under the point of view that we have presented them, and not under this last, that the nervous reproductions should be described.

ARTICLE FOURTH.

DEVELOPMENT OF THE NERVOUS SYSTEM OF ANIMAL LIFE.

I. *State of this system in the Fœtus.*

The nervous system of animal life is one of the first that is developed. If the heart is the first that has motion, the brain is the first that has any considerable size. The disproportion of the head to the other parts is remarkable in the first periods after conception; its size is monstrous when compared with that of the subsequent ages. Now it is evident, that it is the brain that produces this, and that the increase of the size of the bones and the membranes that surround it, is owing to it.

We may say that by creating first the heart and the brain, and developing them much sooner than the other organs, nature wished first to establish the foundations of the organization of the two lives. For on the one hand, it is the brain which is the centre of animal life; it is to this that all the sensations are referred; it is from it that all the voluntary motions proceed. On the other hand, by sending the blood towards all the organs, the heart evidently presides over the circulation, the secretions, exhalations, nutrition, &c. which compose by their union organic life. When these two essential bases exist, nature begins to build, or rather develope around them the double organized edifice, which produces on the one part a communication between the animal and external bodies, and on the other nourishes it.

Notwithstanding these early developments, the brain is not like the heart constantly active; its two great functions, relative to sensation and motion, are almost nothing. The intellectual functions also have but a very obscure action, if they have really commenced at all. The brain is then, if we may so say, in the expectation of action; it has not acted; it requires the excitement of external bodies. I do not say, however, that its inactivity is necessarily entire. It can undoubtedly perceive certain internal motions that take place in the body, and especially the pains that arise there; for if the organic diseases can produce the death of the fœtus, why does it not suffer pain in these diseases? Perhaps the brain is so much the more sensible to it, as it is not diverted by the external senses. The difference of the external and internal sensations, is a question that deserves to be attentively considered. We have seen that the first are uniformly transmitted by the nerves and that the mode of transmission of the second is uncertain. On the other hand the phenomena, the sensation, the impression, &c. are not the same in each; so that an examination of their

relations and their differences is essential. This examination would have much influence upon the knowledge of the kind of animal life that the fœtus can enjoy. Whatever it may be, there can be no doubt but that it is infinitely more contracted than after birth.

The softness of the brain is very great in the fœtus; it is truly a kind of fluid, that the arteries, or rather the exhalants that arise from them deposit in their interstices. These arteries are then extremely numerous; as the brain has a very evident reddish tinge. When it is cut in slices, numerous streaks of this colour are observed in its substance. The two portions, the cortical and medullary, are infinitely less distinct than afterwards, because the second is much less white. The caustic alkali dissolves them at this period of life with great ease. The first effect before a complete solution, is to change the cerebral substance into a glutinous, transparent and viscous matter, a little reddish however, and ropy, almost like the white of an egg. I discovered nothing similar to this in my experiments with the brain of an adult when treated with caustic alkali. The acids coagulate the cerebral substance of the fœtus, it does not however attain by them a degree of hardness equal to what they produce in the subsequent periods of life.

The extreme softness of the brain renders its dissection very difficult in the fœtus.

The nerves of animal life have a development proportional to that of the brain. All of them are very large compared to the other parts; thus the fœtus and the young infant are the most proper for the study of the nervous system, as the less development of the other systems renders this more apparent. Their medullary substance is, like the cerebral and that of the spinal marrow, very soft and even almost liquid under the finger; in this state we can see it in the anterior part of the optic, in which it is

very evident though contained in the canals of the nervous coat, in the posterior part of the same nerve, and in the olfactory where it is found by itself, in the auditory in which it predominates, and finally at the origin of each pair, where its proportion to the nervous coat is very evident.

In all the other nerves it is much more difficult to examine well this medullary substance, because the nervous coat that contains it, is as much or even more developed in proportion to what it will be afterwards. Hence it is that the nerves are very hard and resisting in the fœtus; and that they can support weights proportionably very great. Maceration in water, at a moderate temperature, increases this resistance as in the adult, and renders the nerve harder without increasing its size. We should say that this fluid acts at first upon the nervous coat, in an opposite manner to what it does upon the other animal substances; finally it softens it also, and renders it almost liquid.

The blood vessels are proportionably much larger in the nerves of the fœtus than in those of the adult. These nerves have in their whitish colour, a livid tinge that arises from the kind of blood that enters them; it is the same phenomenon as that of the brain.

The development of the cerebral nerves in the first age presents a phenomenon which essentially distinguishes it from the development of the arteries. These last always follow the increase of the parts to which they go. Thus, the face proportionably less developed in the fœtus, has less large arteries. It is the same of the viscera of the pelvis, whose very small arteries receive but little blood, which does not penetrate and dilate them until the umbilical are closed. On the contrary, the size of the cerebral, gastric arteries, &c. is very considerable. The nerves are absolutely independent in their increase, of that of the parts to which they are distributed. The

olfactory, whose organ is so contracted in the fœtus, has the same proportion as the optic and the auditory, whose organs are already so much developed. It is the same of all the nerves of the voluntary muscles; their proportion of development is uniform, though the muscles vary in their size, according to the regions. If without regard to these regions, we examine in a general and comparative manner the nervous, cerebral and animal muscular systems, we shall see that the first then predominates manifestly over the second, while in the adult it is the muscles, which proportionably to what they were in the fœtus, surpass the nerves that are sent to them. The par vagum which is distributed to organs whose increase is not in the same relation, presents nevertheless the same proportion of size as afterwards, in its different branches.

This double opposite arrangement of the two systems the arterial and nervous cerebral, proves on the one part, the immediate relation of the first with the increase and nutrition, and on the other the small influence that the second exercises upon them.

The nerves are, like the brain, principally inactive before birth, though they have a great development. It is to this that must be attributed the constant absence of their affections at this period.

The nerves are always found in the fœtus, whereas the brain, and even the spinal marrow are sometimes wanting; this is what constitutes acephalic subjects. I shall say elsewhere how the fœtus can thus exist. I would only remark here that the heart, the liver and the other principal viscera of organic life, are on the contrary rarely deficient in the fœtus. Why? Because all the essential organs of this life are necessary, for growth, vegetation and nourishment, phenomena that can take place without the cerebral influence which is principally destined to preside over animal life, which is not particularly in exercise until birth.

II. *State of the nervous system during growth.*

At birth the animal nervous system experiences a remarkable revolution, in consequence of the red blood that penetrates it. Heretofore black blood only circulated in its vessels. The sudden difference that the circulation experiences, has a manifest influence upon its functions. In fact the least foreign substance, differing from red blood, which during life is forced towards the brain by the carotid, is sufficient to produce there a remarkable derangement, and oftentimes even death, as I have frequently convinced myself. Why? because it is not only as a vehicle of nutritive matter, that the fluid sent by the arteries acts upon the brain, but also as an excitant, a stimulant. The change of excitement which the brain suddenly experiences at birth, inevitably increases its vital activity, gives it that which is new and renders it fit for the functions it has never before performed, those of receiving sensations.

Asphyxia is real always when the lungs are not developed after birth, when they do not receive air and consequently do not send red blood to the brain. Some muscular motions may undoubtedly be made; but animal life never begins in its perfection, until the organs that execute it are influenced by red blood. This blood is a general cause of internal excitement. This direct acts simultaneously with the sympathetic excitement that the brain experiences from the skin and mucous surfaces, which the external agents act upon immediately after the exit of the fœtus from the womb. The lungs and the brain influence each other reciprocally at this period, the first by sending red blood to the second, and this by putting in action the diaphragm and the intercostals, which make the air, that is necessary for the production of this red blood penetrate the lungs; hence we see that other excitants act before that of this blood, since

before its formation, the brain has already in it a principle of motion.

Besides, the brain and the whole nervous system are the more powerfully excited by the new principles that the blood has derived from the air, as, 1st. their vessels are in proportion larger and more numerous than afterwards; and, 2d. as all the cerebral arteries enter at that part of the base of the brain, where is found the origin of the nerves, and which is without doubt the most sensitive part of the whole organ.

There is certainly a very great difference between asphyxia that happens to an adult, and the state in which the fœtus is found, since, if the first is prolonged, organic life ceases, while this life is in full activity in the fœtus. Thus there is no resemblance in the composition of the black blood in the arteries in asphyxia and that in the arteries of the fœtus. These two states, however, have a sort of analogy, especially under the relation of the remarkable diminution, of even the absence of animal life, which characterize both. Now in producing asphyxia in an animal at will, by fixing a stop-cock upon the wind-pipe, I have always observed that this life is annihilated when the black blood penetrates the brain, and that when it is in part suspended, it suddenly revives and re-appears by opening the stop-cock, and permitting red blood to enter the brain, nerves, and all the parts. These experiments can, then, to a certain point, give us an idea of the part the red blood takes at birth, in the development of animal life; I say the part, for it is not, as we shall see, the only cause that puts it in action.

For a long time after birth and during the whole of the growth, the nervous system and the brain, which is the centre of it, predominate in their development over the other systems; this predominance is not uniform at all the periods; it diminishes at puberty, when the ner-

vous system is in equilibrium with the others, and the genital organs succeed it in superiority.

This predominance of the nervous system in the infant has an influence on the one hand on the sensations, on the other upon the voluntary motions.

The first influence is very striking. Infancy is the age of sensations. As every thing is new to the infant, every thing attracts its eyes, ears, nostrils, &c. That which to us is an object of indifference, is to it a source of pleasures. As a man receives great enjoyment from a show he never witnessed before, which is blunted by habit if often repeated. It was then necessary that the nervous cerebral system should be adapted, by its early development, to the great degree of action which it is then to have. In fact, all the organs that receive external impressions, the nerves that transmit them, and the brain that perceives them, are really in the infant when awake in permanent excitement, who in the midst of the same objects as the adult, fatigues these organs three times as much as he to whom a great part of these external objects is indifferent, because they have heretofore excited him. Thus observe that the periods of activity of animal life are much shorter in the infant who fatigues his organs in a few hours, in whom, consequently, the want of sleep returns oftener, and in whom this state of intermission of animal life is more profound. It is rare that infants, in the first months, can pass the whole day awake, especially if many objects engage them. We might prolong their wakefulness by removing them from light, sounds, &c.

The multiplicity and frequency of the sensations of the infant, lead necessarily to a number of motions which have not strength, because of the weakness of the muscles, but which are, like the sensations, extremely numerous. As the sight incessantly presents new objects to the infant, it wishes constantly to touch ; its little hands are in continual agitation, its whole body is also in

constant motion. It is necessary that the nerves which serve to transmit the principle of these motions, should be adapted by their development, like those of the sensations, to their constant action.

These two things, the great development of the nervous system and the frequency of its action in the infant, make the diseases of this system the predominant ones at that age. So great is the susceptibility of the brain in answering to sympathetic excitements, that if pains are at all severe in any part, they immediately produce convulsions, which are at least four times more frequent at this age than any of the following. I would observe upon this subject, that the different systems are more or less disposed in the different ages, to answer to sympathies, according as their predominance in the economy is more or less decided. The same morbific cause, fixed upon any organ, which produces convulsions in an infant by acting sympathetically upon the brain, would give to a young girl a suppression of the catamenia, by influencing the womb, which then begins to predominate; to a strong vigorous young man, a peripneumony; to an adult, in whom the gastric viscera predominate, an affection of these viscera, &c. It is thus that the same passions that would give to this one a jaundice, engorgement of the liver, &c. would produce more particularly in an infant an epilepsy, which attacks the brain.

The nervous functions are not only frequently deranged by sympathy in infancy, but it is particularly at this age that the greatest number of organic diseases is found in the brain, the spinal marrow, the nerves, or the organs that depend upon them. Cerebral fungi, hydrocephalus, spina bifida, &c. are a proof of this. The great quantity of blood that goes at that period to the nervous system has much influence upon this phenomenon; now this quantity is brought there by the predominance of the vital forces.

In proportion as the infant grows, its nervous system and the brain, which is the centre of it, lose by degrees the predominance that characterize them. Their diseases become less frequent. They are brought finally to the level of the other systems.

III. *State of the nervous system after growth.*

At puberty, the empire of the brain, which is insensibly diminished, gives place to that of the genital organs, which have a sudden increase. The cerebral nerves appear to me to have but little influence upon their development, as well as upon that of most of the other systems. Observe, in fact, that all the phenomena of generation are governed by the organic forces, which, as we have seen, are absolutely independent of the nerves. Thus the great excitement of the genital organs, from which arise satyriasis, nymphomania, &c. have no analogy with convulsions whose principle is in the brain; as the destruction of the venereal appetite is wholly disconnected with the phenomena of palsies. This is so true, that often during those that affect the lower half of the body by a fall on the sacrum, or by any other cause, the secretion of semen and venereal desires take place as usual.

Beyond puberty, and towards the adult age, when the general equilibrium is more nearly established among the different systems, the nervous is not affected more than those of which we have had occasion to speak in treating of this system.

IV. *State of the nervous system in old age.*

At this period of life, the nervous cerebral system has but very few functions to perform. As to sensation, this being almost blunted by habit, is the reason why external bodies make but little impression upon the organs of sense; many of these, especially the eye and the ear, are

often shut to sensations before general death. The nerves have then but little to transmit, and the brain but little to perceive. As to motion, there is but little in old age, because but little is felt; for feeling and motion are two things that generally follow the same proportion. The brain and the nerves are almost inactive in this respect. The first is not put in action by the intellectual functions; memory, imagination, judgment, attention, &c. all are enfeebled, none are exerted with clearness.

Changes of structure constantly accord with these changes of functions. In the fœtus, the brain is almost fluid; in old age, it is extremely firm. This organ has passed through a variety of gradations between the two extreme ages. We know that anatomists always select the brain of an old person in order to study this viscus, all the parts of which are broken with difficulty. I would observe upon this subject, that what is natural at this age, indicates in a young person a morbid alteration. In general, we have not yet sufficiently studied the comparative anatomy of the different ages, to make applications of it to the examination of dead bodies.

The vessels diminish in the brain in proportion as its hardness increases. In this respect it has an inverse arrangement at the two extreme ages of life. Its colour becomes more dull in old age. It is rare that it is ossified; there are, however, some examples of it. The phenomena, that the action of different re-agents presents, are very much slower in taking place than in the adult and especially in the infant.. The solution by alkalies is a remarkable proof of this.

We cannot doubt but that this organic state of the brain in old age, has much influence upon the preceding phenomena; to this must be referred the less acuteness of pain at this age. A cancerous tumour of an old person, exactly analogous in its position, form, size and nature to that of an adult, produces much less suffering.

Cancers of the womb, the stomach, the breast, &c. furnish examples of this. All the local causes of pain show also the same thing. In the numerous experiments I have made upon living animals, I have uniformly observed, that young ones, when the sensible parts are cut, give signs of the most acute pain; whilst old ones show infinitely less expression of it under similar circumstances. I would make one other remark upon this subject; it is that the variety appears in dogs, in a certain degree to have an influence upon the acuteness of their sensations. All the large varieties make but little noise, and are not much agitated, when their skin, their nerves, &c. are cut; whilst all the small ones, though they may be old, struggle, are agitated, and manifest upon the slightest cause, the most acute sensibility.

As to the influence of age upon pain, it is not astonishing that the animal sensibility having become very obscure in a natural state, should preserve the same character in disease. An old person suffers then much less than the adult, and especially than the infant, under the influence of the same causes; it is a compensation for the diminution of their enjoyments. The infant finds in every thing that surrounds him, a cause of pleasure or of pain; thus smiles and tears succeed each other a hundred times a day upon his little face. An old person on the contrary is always calm; indifference is his natural state.

The nerves experience the same changes as the brain; they harden gradually with age; however their proportion of hardness in the first and last ages is much less remarkable than that of this organ; this arises from the nervous coat; for the effect upon the medullary substance appears to be the same. This medullary substance has appeared to me to be less abundant in the optic nerve of an old person; however it is difficult to determine the quantity. The colour of the nerves becomes dull, like

that of the brain. They receive fewer vessels. They are never ossified.

Sometimes we say that the extremities of the nerves have become callous; it is a vague expression, to which no meaning can be attached. When will medical language cease to refer to the empty and inaccurate hypotheses that formerly constituted medicine? Most of these hypotheses have passed away, yet the names to which they gave birth remain.

The nervous system and the brain frequently lose beforehand, in old people, a part of their functions; hence hemiplegia is almost as frequent at that age, as convulsions which are its opposite, are in infancy. It is necessary to distinguish the hemiplegias of old people from those of adults. They are of the same nature as the blindness, the deafness of old people; the difference is only in the injury of sensation or motion.

NERVOUS SYSTEM OF ORGANIC LIFE.

GENERAL REMARKS.

NO anatomist has yet considered the nervous system of the ganglions in the point of view in which I shall present it. This point of view consists in describing each ganglion as a distinct centre, independent of the others in its action, furnishing or receiving particular nerves as the brain furnishes or receives its own, having nothing in common, except by anastomoses, with the other analogous organs; so that there is this remarkable difference between the nervous system of animal life, and that of organic life, viz. that the first has a single centre, and that it is to the brain that every kind of sensation comes, and that it is from it every kind of motion goes; whilst in the second, there are as many little separate centres, and consequently little secondary nervous systems, as there are ganglions.

We know that all anatomists, even those who, without affixing to the expression any very definite meaning, have called the ganglions little brains, have taken them for dependancies, for enlargements of the nerves, in whose course they are found; and as most of them are met with in the great sympathetic, they have presented them as a distinctive character of this nerve. But from the general idea I have just given of the ganglions, it is evident that this nerve has no real existence, and that the continuous thread that is observed from the neck to the pelvis, is

nothing but a succession of nervous communications, a series of branches that the ganglions placed above each other, send reciprocally to each other, and not a nerve going from the brain or the spine.

The first considerations that induced me to think that the great sympathetic is not a nerve like the others, but a series of anastomoses, were the following. 1st. These communications are often interrupted, without any inconvenience, in the organs to which the great sympathetic goes. There are subjects, for example, in whom is found a very distinct interval between the pectoral and lumbar portions of this pretended nerve, which seems cut in this place, because the last pectoral ganglion and the first lumbar do not send branches to each other. I have often seen also the sympathetic nerve cease, and afterwards appear again between two ganglions and from the same cause, whether in the loins, or in the sacral region. 2d. Every one knows that the opthalmic ganglion, the spheno-palatine, &c. are constantly distinct, and that they do not communicate by their branches except with the cerebral nerves. It uniformly happens that there is between them and those of the great sympathetic, what we sometimes see between these last, viz. a complete deficiency of communication. 3d. In birds, as has been observed by Cuvier, the superior cervical ganglion is also found constantly distinct; it never communicates with the inferior. The filament which in quadrupeds descends the length of the neck, is wanting in them. In many other animals we frequently find interruptions in this succession of anastomoses of ganglions, which constitute what is called the great sympathetic. 4th. The communications of the ganglions are usually made by a single branch; but sometimes many go from one of these organs to the other, so that if the great sympathetic was a nerve like the others, it would present, in this respect, an arrangement wholly different from that of the cerebral nervous

system. 5th. Whence does the great sympathetic arise? From the sixth pair? But all the nerves diminish as they go from the brain towards the organs; but this presents then an arrangement entirely different; it increases as it sends off branches. Does it arise from the spinal marrow? But then the branches with which it furnishes a region would come from the branches that it receives from the spinal marrow in this region. Thus the great and small splanchnic would arise from certain intercostal pairs, now they are evidently much larger, the first especially, than the sum of the branches from which they would derive their origin. Observe then that all anatomists have been of a different opinion upon the origin of the great sympathetic. How could they agree upon a thing that has no real existence?

These different considerations render probable the opinion that I have entertained for some time, that the great sympathetic nerve does not really exist, that this cord is but a succession of communications between little nervous systems placed above each other, and that it is not essential that these communications should exist, as is seen constantly between the ophthalmic ganglion and the spheno-palatine, between that and the superior cervical, of which many animals furnish examples. Then I began to regard each ganglion as a separate centre of a little nervous system, wholly different from the cerebral, and distinct even from the little nervous systems of the other ganglions. By considering the functions of the nerves going from these centres, I became more and more convinced that they did not belong to the cerebral system. In fact, these nerves have properties very different from theirs, as we shall see; they do not serve for sensations; they have uniformly no connexion with voluntary locomotion; we see them only in the organs of internal life; hence why they are found concentrated in the trunk, in the thorax and abdomen particularly; why they are

not met with in the head, where almost all the organs belong to animal life; why they are not seen in the extremities, which are exclusively dependant upon this life.

Distributed almost every where to the organs of the internal life, the ganglions and their nerves derive their character from it; and this is it. 1st. They are not symmetrical; thus the nerves of all the plexuses of the abdomen, those of the cardiacs, &c. have a remarkable irregularity. 2d. There are numberless varieties in the form of these plexuses and in that of the ganglions; it is thus that, sometimes lenticular, sometimes triangular, sometimes divided into many portions, that which is under the diaphragm is never seen twice alike. Hence the error of every name derived from the figure; a remark that is applicable generally to the organs of internal life. We might rather borrow the names of forms for animal life in which these forms are more invariable. On the other hand, the existence of many ganglions varies; sometimes there are three of them in the neck, at others but two. The arrangement of one side does not produce a similar one on the other. I have frequently remarked that the number of filaments arising from the superior cervical ganglion differs very much from those that take their origin from the opposite side. There are two analogous organs at each side; but several attributes of structure destroy the general character of symmetry; it is like the lungs and the kidnies. We can, then, establish as a distinctive character between the two nervous systems, the symmetry of one and the irregularity of the other; now, this character is one of those which distinguish the two lives, as I have remarked before.

From all this it is evident that a line of demarcation separates the nerves of the ganglions and those of the brain, and that the method is inaccurate which considers them as forming a single nerve, arising by some origin from this last. Their communications no more prove it

to be a general nerve, than the branches which pass from each of the cervical, lumbar, or sacral pairs, to the two pairs that are superior or inferior to it. Notwithstanding these communications, we consider each pair in a separate manner, and not as one nerve by their union. So that each ganglion should be described separately, notwithstanding the branches it sends to others.

The description of the system of the ganglions should be analogous to that of the cerebral nerves. For example, I describe first the lenticular ganglion, as was done for the brain ; then I examine its branches, among which is found the great splanchnic ; for it is very improper to say that this nerve gives origin to this ganglion. The same in the neck, in the head, &c. each ganglion is first described ; then I treat of its branches, among which are found those of communication. There are, then, almost as many descriptions as there are separate ganglions. For example, we ought not to treat of the ophthalmic nerve with the common motor ; to be convinced of this, it is sufficient to see how much the ciliary nerves differ from the others, which, belonging to animal life, are also contained in the orbit.

From all that has been said, it is evident that there are two things to be examined in the nervous system of organic life, 1st. the ganglions ; 2d. the nerves that go from them.

ARTICLE FIRST.

OF THE GANGLIONS.

I. *Situation, forms, relations, &c.*

The ganglions are little reddish or greyish bodies, situated in different parts of the body, and forming so many centres, from which goes an infinite number of

nervous ramifications. Their position most generally is along the vertebral column, where are seen successively below each other, the superior and inferior cervical, the intercostal, the lumbar, and the sacral. It is these especially whose communicating branches form the great sympathetic. But besides these ganglions, which are placed as it were in a row, we find many separate ones in different parts, as the ophthalmics, the spheno-palatines, the maxillaries in the head, as also the semilunars in the abdomen. In the thorax there are none thus separate; though sometimes we see a small one at the base of the heart.

Besides the ganglions uniformly seen, there are often accidental ones, if we may so say; such are those that are sometimes found in the hypogastric plexus, in the solar even, at some distance from the semilunar, in the middle part of the neck, &c. On the other hand, some of those that are usually met with are oftentimes not found, as some of the lumbar, sacral, maxillary, &c.; so that it appears that there is really an essential difference between the ganglions under the relation of existence. The superior cervical, the semilunar, the ophthalmic, &c. are always found; they appear to be essentially necessary to the action of the organs to which they furnish nerves. Most of the others may be wanting on the contrary, and be supplied by those of the neighbouring ones, or by others formed not in the ordinary anatomical order.

All the ganglions are generally in a deep situation. Destitute of a bony covering analogous to that of the brain, they are not less powerfully protected against the action of external bodies. It is this deep position, that prevents us from making experiments upon almost all of them, from making those at least which require that the animal should live a certain time after they have been made. It is this which will undoubtedly keep up for a

length of time the obscurity that hangs over the functions of these organs.

The form of the ganglions is extremely irregular. In general they are round ; but sometimes they are long, as the superior cervical ; sometimes the ganglion is a species of triangular body, with obtuse and round ends, as the ophthalmic ; sometimes the form is semilunar, like that which has this name, &c. Generally these forms are very variable, as I have said ; the most uniform is that of the superior cervical.

Embedded in a quantity of cellular texture, all the ganglions are separated by it from the neighbouring organs. Almost all of them are so disposed, that they experience but little motion from these organs, and cannot receive it from any of the vessels that enter them. Those situated along the vertebral column especially, present this phenomenon, very different from that which takes place at the brain, whose functions are essentially connected with the constant agitation that the blood imparts to it, and very different from that which we observe in the plexuses of nerves coming from these same ganglions.

II. *Organization.*

The ganglions have generally in the adult a reddish colour very different from that of the nerves ; sometimes they are greyish. When opened, they present a soft, spongy texture, resembling considerably at first view that of the pretended lymphatic glands.

This texture has nothing in common with the cerebral substance, nor with that which occupies the canal of the nervous coat. These two last should rather be ranked in the class of fluids, as I have said ; their substance is a pulp, a real jelly. Thus they have not any of the properties of solids. They do not harden like horn ; the kind of hardening, the result of the contact of alkohol, of the acids,

and of caloric, is wholly different from the horny hardening. It is analogous to the hardening of the white of an egg. On the contrary, the texture of the ganglions hardens like horn in an evident manner, a phenomenon which is characteristic of all the solids, except the epidermis, the nails, and the hair, which make a separate class. Treated by the acids, the ganglions, after wrinkling, hardening like horn and hardening gradually, soften and become fluid.

Boiling produces a phenomenon nearly analogous; 1st. horny hardening and hardening at the instant the water boils; 2d. continuance of this state for half an hour; 3d. softening gradually brought on; when this last is complete, the effect of the boiling is finished. In this state, the ganglions are all different from the nerves submitted to the same experiment. I have observed also in veal, that they have a very different taste from that of the nerves, a method of research which should not be neglected in attempting to ascertain the difference of the nature of the organs. In fact, as we do not yet know the difference of the principles which enter into the composition of each, we should be satisfied with the difference of the qualities.

The alkalies act a little upon the ganglions, which they tend to dissolve, and which they do partly dissolve, if they are very caustic. But this solution is infinitely less prompt and less easy than that of the cerebral pulp by the same re-agents. The ganglions resist putrefaction as much and even more than the nerves; this forms also a very remarkable difference between them and the cerebral substance. In general, we cannot establish any kind of analogy between them.

The texture of the ganglions appears in nowise fibrous; there is absolutely no linear, filamentous appearance, &c. upon simple inspection. Homogeneous, if we may so say, in its nature, it presents every where an uniform

aspect when cut in slices. However the celebrated Scarpa has considered the ganglions as resulting from a kind of expansion of the nerves, into an infinite number of extremely delicate fibres, which interlace with each other, and which become very distinct by maceration. I have not repeated all his experiments, which appear to me extremely difficult. I refer then to his work, and to the plates it contains. I would observe only that there is certainly something else in the ganglions, besides a simple division of the nerve into extremely fine threads. In fact, mere inspection is sufficient to establish between them the greatest difference. There is as evident a demarcation between the ganglions and the nerves, as between those of the brain and the brain itself. 1st. Difference of colour, reddish or greyish tinge in some, white in others; 2d. difference of consistence, of external qualities, &c.; 3d. difference of properties. If the nerves coming from the spinal marrow make only an expansion, in their passage, in the ganglions, by delicate filaments, there would then be only a difference of form and not of nature; the properties would be the same. Why then are they so different as I shall prove hereafter? Why, as a nerve goes from a ganglion, does it not communicate more voluntary motions? 4th. Why has not nature placed ganglions in the nerves of the extremities as in those of the other parts? If there is only a division of the nerve into finer filaments, in the ganglion, why is there not a proportion between the filaments that enter on one side, and those that go out at the opposite? In fact, those that enter into the superior cervical above, if they only expanded their filaments in this ganglion, and united afterwards to form those that go off below, would be equal in respect to size to those that go from it; all the ganglions would exhibit this constant relation between the nerves of one side and those of the opposite; now, it is sufficient to examine them to be convinced that an inverse arrange-

ment exists. 6th. The ganglions ought always to be in proportion to the size of the nerves which form them by spreading their fibres. Why then are the intercostal ganglions so small, and the trunks that unite them, or rather that give origin to them and which go from them afterwards as we see in the usual manner, so large? Why on the contrary, is the superior cervical ganglion so large, and its branches so small? 7th. How can be explained the frequent interruptions between the ganglions in man, which are constant in many animals, if there is a continuity between the nervous filaments that enter the ganglions above, and those that go from them below? 8th. How does it happen that the ganglions and their nerves do not follow an exact proportion as to development with the cerebral nerves, if these form them by expanding? 9th. Why has not pain the same character in each species of nerves?

I have no opinion as to the nature or the functions of the ganglions, because I have no fact to support me; but there is certainly something more in their texture, than a mere expansion of nervous filaments. Scarpa admits a peculiar matter which separates these filaments; but this substance ought to predominate considerably, as the ganglion surpasses in size the nerves which are thought to give origin to it. Now I have never seen this substance; I do not know what it is; all is solid when the ganglion is cut. I think then by admitting, even to a certain extent, the internal arrangement that this author has observed in the ganglions, we cannot describe these organs in the point of view in which he has presented them.

We know but little of the alterations that diseases produce in the texture of the ganglions. I have already many times examined in diseases of the heart, of the liver, of the stomach, the intestines, the ganglions that send nerves to these viscera; they have never appeared to

me to have undergone any change. In cancers of the stomach in the very last stage, in which all the cellular texture is engorged, and in which all the lymphatic glands are considerably swelled, I have always found the semilunar ganglion untouched, except however in one case where it was enlarged and its density a little increased. At another time I found this same ganglion of the size of a small nut, with a cartilaginous substance in its centre, resembling the stone of it, in the body of a man brought to the Hôtel Dieu on account of periodical mania. Some authors have thought, and I suspect the same thing also, that the hysteric paroxysms, which begin by a contraction at the epigastric region, and in which the patient feels a ball mount up even to the throat, arise from some affections of the semi-lunar ganglions, from the solar plexus and the communications which go from ganglion to ganglion, even to the neck. However two bodies that I have opened lately, exhibited no alteration, though during life the subjects had been frequently attacked with these paroxysms; but they may arise evidently from the ganglions and the epigastric plexuses, without their being altered in their structure, as a number of cerebral affections leave after them no trace in the brain. This point deserves particular examination.

It does not appear that the texture of the ganglions is surrounded by a peculiar membrane. The cellular texture is only condensed in their neighbourhood; it then becomes very consistent, and much contracted around them. It there has the nature of the sub-mucous, the sub-arterial textures, &c.; it never contains fat. There is then truly around the ganglions, as around the arteries, under the mucous surfaces, &c. the two kinds of cellular texture of which we have spoken in treating of the organization of this texture, and which differ so essentially from each other in their nature, and even in their properties. It is the second kind, which is analogous to the

sub-arterial texture, &c. which forms the peculiar membrane admitted by some authors.

By examining attentively the interior of the ganglions, we see that there is but very little cellular texture there. I have found this texture constantly destitute of fat; thus the alkalies do not form a saponaceous deposit upon them, as upon the cerebral nerves when plunged in their solution. I have examined many ganglions in this way, on account of the opinion of Scarpa, who believes that these organs are penetrated with this fluid, at least in fat people.

The ganglions receive many blood vessels. These penetrate them from all sides, run first in a kind of cellular covering that surrounds them, then entering their texture, ramify and are lost there in numerous anastomoses, and in continuation with the exhalants that carry nutritive matter. Fine injections show a great quantity of vessels in these little organs. Nutrition supposes exhalants and absorbents there.

III. *Properties.*

It is difficult to analyze the properties of texture in the ganglions. As to vital properties, they cannot grow, live and be nourished without organic sensibility, and without insensible contractility of the same kind. Animal and sensible organic contractility do not exist there evidently. As to animal sensibility I have observed the following circumstance. As in opening the abdomen of an animal, of a dog, for example, he lives very well for some time, and remains even calm after the first moments of suffering; I have waited for this calm that succeeds the agitation arising from the incision of the abdominal parietes, then laid the semi-lunar ganglion bare, and irritated it powerfully; the animal is not agitated, whilst when I excite a cerebral lumbar nerve, for comparison, he cries out, raises himself up and struggles. In general it ap-

pears that the sensibility of the ganglions is infinitely less evident than that of many other organs. Certainly the skin, the mucous system, the medullary, the nervous of animal life, &c. surpass it in this respect.

Our ignorance as to the diseases that have their seat in the ganglions, the distance of those organs from external excitement, prevent our having any data as to their sympathies. I think it very probable, however, that these sympathies take a real part in hysteria, in certain kinds of epilepsy, the paroxysms of which begin, like those of hysteria, by a painful sensation at the epigastric region, in that multitude of affections called nervous, and which the vulgar confound under the name of vapours. One of the most important objects of research in the neuroses, is to determine those that have their particular seat in the nervous cerebral system and those which affect more particularly the system of the ganglions. Place on one side, palsy, hemiplegia, convulsions of infants, tetanus, catalepsy, apoplexy, the greatest part of epilepsies, all the numerous accidents that arise from engorgements, from compressions of the brain from wounds of the head, nervous affections of the sight, hearing, taste, smell, &c. and all the diseases the source of which is evidently in the head; on the other place hysteria, hypochondriasis, melancholia and all that numerous class of affections in which the abdomen and the thorax, the first especially, seem to be the spot in which the evil is seated; you will see that there is an essential difference and that the symptoms have entirely a different character. I do not say that the last kind of nervous diseases affect exclusively the ganglions; for too much obscurity hangs over these affections to pronounce any thing positive as to their seat, or their nature. Undoubtedly even the secretory, circulating, pulmonary organs, &c. can be then particularly affected in their peculiar texture and independently of the nerves they receive; but certainly it is an interesting sub-

ject of research, and there is too great a difference in the phenomena of the two orders of affections, not to present differences in their primitive seat. It is difficult to conceive that the system of the ganglions has not a great part in the last order.

That which induces me to think that the difference of the phenomena that the general order of neuroses presents us, arises particularly from the difference of the cerebral nerves and of those of the ganglions, is that their phenomena in a state of health are very different. Hallé has observed very well that the pains that are experienced in the parts in which the nerves coming from the ganglions are distributed, have a peculiar character, and that they do not resemble those that are felt in the parts where the cerebral nerves are sent. Thus the painful sensation that is experienced at the loins in affections of the womb, by vinous injection made into the tunica vaginalis, &c. a sensation that appears to me to arise from the sympathetic influence exercised by the organ affected upon the lumbar ganglions, the pains of the intestines, the burnings at the epigastric region, &c. &c. do not resemble pains of the external parts; they are deep, and go to the heart, as we often say. We know that there are colics essentially nervous, which are certainly independent of every local affection of the serous, mucous, and muscular systems of the intestines. These colics are evidently seated in the nerves of the semi-lunar ganglions, which are spread along the whole course of the abdominal arteries. They are real neuralgias of the nervous system of organic life; now these neuralgias have absolutely nothing in common with the tic douloureux, sciatica, and other neuralgias of the nervous system of animal life. The symptoms, the progress, the duration, &c. every thing is different in these two kinds of affections.

What I have just said upon the injuries of sensation, applies also to those of motion. No kind of comparison can be made between the convulsions of the muscles that receive the nerves of animal life, and the spasmodic and irregular motions which arise in all the muscles that receive nerves from the ganglions. Nothing resembles tetanus in the heart, the intestines, the bladder, &c.

All these considerations establish striking differences between the cerebral nerves and those of the ganglions; differences upon which I can only present approximations, as we have no data as to the functions of the last.

IV. *Development.*

The ganglions differ essentially from the brain in the early periods in their development, which is proportionably much less advanced than that of the brain. They are only on a level with all the other organs, whilst this is infinitely superior to them in this respect, as we have seen. By comparing the superior cervical, semilunar ganglions, &c. in the fœtus, and in the adult, it is easy to make this remark. The ganglions receive also less vessels in proportion than the brain. They do not follow the proportion of increase of the organs to which they send nerves. Thus those that furnish the genital organs, which are nearly nothing during the first years of general nutrition, are as large in proportion as those which go to the liver, the stomach, the intestines, which are characterized by an early increase. These nerves follow in this respect the same law as the ganglions, though the most are found upon the arteries, which are more or less developed according to the organs they penetrate.

The nervous system of organic life being less early in its development than that of animal life, should be subject in infancy to fewer affections; and this is what is observed. Convulsions, and most of the neuroses of the second, are, as we have seen, a peculiar appendage upon

infancy. On the other hand, the particular order of nervous affections of which we have spoken, and in which it appears that the first takes the principal part, is generally less frequent at this period. All nervous diseases, whose peculiar seat seems to be at the epigastric region, in which there is so great an abundance of nerves coming from the ganglions, appear to be foreign to this age.

Another difference that distinguishes the ganglions from the brain as it respects development, is this, that in the fœtus, they are not, like it, of extreme softness. Their hardness is little inferior to what they afterwards possess in adult age.

In proportion as we advance from infancy, the organic nervous system begins to become predominant. It is towards the thirtieth or fortieth year that it appears at its maximum of action; it diminishes as we approach old age; it decays in part at this epoch. The nerves become greyish; the ganglions are hard, resisting and smaller. The neuroses that appear to belong to them are infinitely more rare. Moreover, the obscurity that rests upon the functions of this system, does not allow me to point out definitely the alterations they experience in the different ages.

V. *Remarks upon the vertebral ganglions.*

In all that I have said thus far upon the ganglions, I have not noticed those which correspond with the foramina through which the nerves pass, and which some call simple ganglions. We know that at the instant each nerve goes from each of these foramina, it exhibits an evident enlargement, reddish, pulpy, analogous in its appearance to most of the ganglions. I confess, that I know not how to class these organs. We cannot deny that they have the greatest analogy in structure to the others. They are approximated in another respect, which is this, that the nerves, in going from them, form

almost immediately plexuses that we have designated under the names of cervical, brachial, lumbar, and sacral, in the same way as the solar, cardiac, mesenteric plexuses, &c. are formed by the nerves of organic life, at the moment they go from their respective ganglions. However, these last nerves are conductors of very different properties. Irritate in a living animal the superior cervical ganglion, the inferior even, which is more difficult, though it may be come at, the muscles to which they send nerves will remain unmoved; the same phenomenon takes place by exciting the nerves themselves. On the contrary, every irritation of a filament coming from the vertebral ganglions, produces immediately convulsions in the corresponding muscles. The sensibility is entirely different in the two species of nerves. Besides, there is no analogy between the manner in which the nerves go in all directions from the vertebral ganglions, and that in which the other ganglions furnish theirs. In the expectation that further experiments may elucidate the subject, let us content ourselves with pointing out what is the result of accurate observation.

ARTICLE SECOND.

OF THE NERVES OF ORGANIC LIFE.

I. *Origin.*

Each ganglion is, as we have seen, a centre from which go in different directions, various branches, the whole of which form a kind of little separate nervous system. The manner of the origin of these branches has but very little relation with that of the branches of the brain and of the spinal marrow. The following are some differences that distinguish it.

1st. The adhesion is much stronger; the nerve breaks any where else rather than at its origin; the opposite of this takes place in the preceding system. 2d. It does not appear that the substance of the ganglion is continued in the nerve to form the medullary substance of it, since the organization of the one and the other is very different. Sometimes, however, the ganglion is continued for a short distance in the form of a cord. This happens especially in the superior cervical, in the lumbar, the semilunar, &c. Then the form only is different; but it is easy at the first view to distinguish where the ganglion ends and the nerve begins. 3d. This beginning is made in a sudden manner; it is like a muscle implanted in a tendon. The best manner of seeing this arrangement to advantage is to cut longitudinally the superior cervical ganglion and the cord it sends to the inferior; the change of nature of the one and the other is then very apparent; or, if we consider the ganglion as a division of the numerous filaments of the nervous cords, we distinguish very well the sudden change that these filaments experience in passing from the cord to the nerve. 4th. The dense cellular covering that surrounds the ganglion is continued upon the nervous origin, and gives it an increase of consistence at that place. This must be carefully raised before we come to the nerve. We see then each distinct filament arising from the ganglion. After it has gone from it, sometimes it remains separate; this takes place at the semi-lunar, the lumbar, the opthalmic, whose elongations are of great delicacy. Sometimes many of these filaments unite together and form a cord as between the two cervical, as at the great and small splanchnic nerves, &c.

I have not been able by maceration, ebullition, or the action of the acids to destroy the adhesion of the nerve with the ganglion, as we destroy that of the muscle with the tendon, of this with the bone, &c.

II. *Course, Termination, Plexuses.*

The nerves after going from the ganglions, are distributed in many different ways which we shall now examine.

1st. There are always some which go immediately to communicate with the system of animal life. The ophthalmic ganglion sends branches to the motores communes, and to the nasal nerve. The spheno-palatine communicates with the superior maxillary nerve; the superior cervical with all the nerves that surround it, viz. above with the motor externus, within with the great hypoglossal, the par vagum, the glosso-pharyngeal, the spinal, &c.; behind with the first cervical pairs. All the ganglions situated above each other along the vertebral column, send communications through each pair of foramina that correspond with them. The par vagum communicates with the semi-lunar, &c. It is not then any separate ganglion of the nerves of animal life; hence the common expression that designates each ganglion as arising from this or that pair, or being found in its course, is very inaccurate. Thus the opthalmic is by no means in the course of the common motor nerve. The one and the other send each a branch, which unites; or rather there is a branch of communication between the ganglion and the cerebral nerve. In general all these branches of communication with the system of animal life, are short, whitish, and of the same nature, or at least of the same appearance as the nerves of this last. They do not form any plexus in their course, rarely furnish branches, and appear to have no other use than that of establishing anastomoses between the two systems.

2d. Each ganglion sends above and below branches to the two ganglions that are contiguous to it. We have seen that the opthalmic and the spheno-palatine are exceptions to this rule. Sometimes also, as I have said,

there are interruptions in other regions. Notwithstanding this, these general communications make us regard the ganglions as being connected every where, and able to receive from each other the different affections of which they can be primitively the separate seat. These branches of communication are straight as in the preceding, sometimes very fine, as between the lumbar and sacral ganglions, at other times larger, as that which is between the two cervical, superior and inferior, in some cases very large, as the great splanchnic, which is a real trunk of communication between the intercostals and the semi-lunar. The nerves that we are now considering, the last especially, have like the preceding, an arrangement exactly analogous to the cerebral nerves; they are formed of whitish cords, which are the result of filaments. The eye discovers no difference between them.

3d. Many filaments coming from ganglions, go to certain cerebral muscles, as to the diaphragm, some of those of the neck, &c.; others go to neighbouring organs only.

4th. The greatest number going from the ganglions in separate filaments, interlace in the form of a plexus with those of the contiguous ganglions, in the neighbourhood of, or upon the great vessels. The most remarkable plexus is the solar, composed by the innumerable branches that come from the semi-lunar; then we see the hypogastric, the cardiac, &c. The greater number of these plexuses are not exclusively formed by the nerves of organic life; those of the animal give some to them also, as the par vagum furnishes an example for the solar and the cardiac, as the sacral nerves afford another for the hypogastric, &c. However the nerves of organic life always predominate in these plexuses. There is only the pulmonary in which the par vagum particularly predominates, whilst the nerves coming from the inferior cervical ganglion are, if we may so say, but accessory.

The primitive plexuses resulting from the interlacing of the organic nerves at their exit from the ganglions, form a mass of irregular nerves, buried in the cellular texture, accommodated to the forms of the neighbouring organs, and wholly different from those of animal life, as of the brachial, the lumbar, &c.

In fact, the filaments at every instant, not only place themselves as in the preceding ones, at the side of each other, at every change of position; but their extremities continue; they interlace with each other, change at every point the direction, form networks, and mix so together, that it is not possible to distinguish any thing except a thousand nerves, that we might say grew up under the cloth with which we wiped the place where the plexus was found.

These organs are remarkable for their reddish or greyish colour, for their softness, for their indistinctness, &c.; it is often difficult to distinguish them from cellular texture. The best manner of making them evident is to let the subject macerate for a day or two open in the water; they whiten then sensibly, do not soften, and appear even to increase in consistence, like the cerebral nerves in a similar case. Besides their delicacy is such, that it is impossible to submit them to any kind of reagents. Only I have observed that they possess in an eminent degree the property of horny hardening, and that they do not yield in this respect to the cerebral. This delicacy depends upon this, that all the filaments are separate from each other, instead of being like the preceding, collected into cords; it is this also that makes these nerves so numerous. If all the filaments of the brachial plexus were separated like those of the solar, they would present the same appearance and the same number in their interlacing.

Do the primitive plexuses formed by the ganglions perform a part in the nervous functions? are they centres to

which are referred important phenomena? What has not been said upon this subject, concerning the solar plexus? But nothing, I believe, of all that has been advanced is founded upon accurate observation.

The plexuses of organic life are soon separated into different divisions, which go to different parts, to those especially of this life. These divisions arise from an infinite number of little filaments which go constantly separate, though placed near each other, and which never unite into cords like the preceding. They accompany almost all the arteries; thus the renal, the hepatic, the splenic, the coronary stomachic, the mesenterics, the hypogastric, the carotid and its distributions, &c. are surrounded with filaments coming from ganglions. These filaments go in two ways. 1st. Some accompany the artery without being connected with it; considerable cellular texture separates them; they go in its course without intermixing in a sensible manner with it. 2d. The others form for it, if we may so say, a new coat, exterior to the others, which adhere to it intimately, and which interlace so together, that they might be taken for a network surrounding the artery.

When the artery runs but a short course, these two orders of branches remain distinct from each other as far as the organ, as we see around the splenic, the hepatic, the renal, &c.; but if the course is longer, the external branches gradually get into the plexus, and are entirely lost there. This plexus can be followed upon the great trunks; it divides upon each branch, and can be still seen; but such is its tenuity upon the minute ramifications that it disappears there entirely. The spermatic is one of the arteries upon which it can be traced the longest. The arteries of the extremities appear to be destitute of it. In general it is upon those that go to the central organs of internal life, that this network is the most evident. When we deduct from the sum of the filaments

coming from the ganglions, those by which they communicate on one part with each other, and on the other with the nerves of animal life, we see that almost all the rest is finally destined to accompany the arteries. This arrangement is wholly different from that of the cerebral nerves, whose filaments are only in apposition with the vessels. These make almost an integrant part of them, the adhesion is so intimate; this certainly supposes a use of which we are ignorant, relative to the circulation, or to the other organic functions. As these vessels distribute every where the materials of these functions, of the secretions, exhalations, nutrition, &c. the organic nerves have no doubt some influence upon them. Neither experiment or observation have taught us any thing upon this point.

The veins are not accompanied by so many organic nerves. It is the same as it respects the absorbent trunks, which go almost every where separate from this system.

The constant union of the arteries with the organic plexuses, an union that presents an arrangement wholly different from that of the ganglions, has undoubtedly an influence upon the action of these plexuses, or rather upon that of the nerves that go from them, by the motion the blood communicates to them. It should be remarked upon this subject, that as nature has placed a crowd of arteries at the base of the brain to agitate it with an alternate motion, she has put also the most considerable plexus of the whole organic system upon one of the places to which the red blood communicates the strongest impulse, viz. upon the trunk of the cœliac.

III. *Structure, Properties, &c.*

From what has been said above, it is evident that the nerves going from the ganglions are of two sorts as it respects organization; 1st. those that are identified with

the cerebral system, by their white colour, by the possibility of dividing their trunks into distinct cords, and these into filaments, which appear to have nervous coats and medullary substance like the preceding; 2d. those which present only little separate filaments, greyish or reddish, soft, and which are seen in prodigious numbers in the plexuses. Have these a nervous coat and a medullary substance? It is impossible to determine it.

The properties of texture are ascertained with difficulty in the organic nerves. As to vital properties, it is undoubted that the animal sensibility is not as much raised in these nerves as in those of animal life. I have often laid bare the plexuses in the abdomen; then by letting the animal rest a moment, and by irritating them comparatively with the lumbar nerves, I have uniformly made this remark. We know that very frequently the ligature of the spermatic artery is not painful in sarcocele, though the branches coming from the ganglions form for it a plexus like a network, which can in no way be separated from it. If we draw out a portion of intestines by a small wound in the abdomen, the irritation of the sub-mucous layer at the side of the vessels, is hardly felt, though many nerves of ganglions are found at this place. I have had numerous occasions to act in different ways upon the carotid, to which the superior cervical ganglion furnishes branches from above; now, as long as I did not touch the par vagum, the animal remained tranquil. I am far, however, from believing in the absolute insensibility of the nerves of the ganglions; but certainly under the circumstances that I have related, the cerebral nerves would have caused much more pain to the animal.

I think that in a morbid state this sensibility is susceptible of being greatly raised. We certainly cannot deny but that the solar plexus takes a great part in the different sensations that are experienced at the epigastric region; the very acute pains that often attend the forma-

tion of aneurisms, are probably owing in part to the distension of the nervous filaments that surround the artery. I have already said that it is probable that the organic nerves are much concerned in the different sensations that are produced by some peculiar neuroses.

These nerves occasion evident sympathies in certain cases. It is to this that must be referred the different affections that Petit de Namur has produced in the organ of sight, by irritating their branches that are accessible. The development of the nerves of the ganglions follows nearly the same laws as that of those organs from which they emanate.

Let us observe in finishing this system, that there is no one that ought to arrest the attention of physiologists more. All the others present a series of phenomena already well known. Of this, we have hardly any knowledge. It does not present as yet, if we may so say, but some of the negative attributes of the nervous system of animal life. Thus it is without doubt that the organic nerves do not have the same part as the preceding in animal sensibility; that they are always foreign to contractility of the same species; that they have no direct influence upon the sensible organic, since as we shall see, we can cut or irritate them without destroying or hastening the motion of the muscles to which they go. But in knowing the parts they do not perform we are ignorant of those to which they are really destined. I have already observed that the difficulty of making experiments upon the ganglions and the plexuses, will much retard the progress of science. We have scarcely any branches upon the exterior upon which we can act.

Scarpa has collected the opinions of all who have preceded him, together with his own, upon the uses of the ganglions. I refer to what he has said upon this subject. As the general point of view in which he has presented these organs, and that in which I offer them here, differ

essentially, the account that I have just given of the nerves of organic life has necessarily a general stamp wholly different from that of his work, a work, however, which, like all this author has published, confers the greatest honour upon the state of anatomy at the period in which we live.

I will terminate this article by an important reflection. If the nerves were only divided to form the ganglions, if these presented in their interior only differences of forms, and a very minute division of their filaments, why should they be so constant in animals? Many organs are wanting, vary, are presented under a thousand various forms in their different classes; on the contrary, the ganglions are constant. In those species even in which the cerebral system is imperfect, that of the ganglions is complete in its organization. Animal life diminishes and is contracted in an evident manner in most insects, in worms, &c. and generally in animals without verterbræ. The brain and the nerves become less evidently marked in proportion as this life is less perfect. The organic is, on the contrary, almost in its perfection in these animals. The ganglions and their nerves are also very evident. This remark has struck me in reading the researches of different authors upon the anatomy of the lower classes of animals; now, if the ganglions were not the centres of certain important functions of which we are ignorant, would they be so invariable in the animal organization?

VASCULAR SYSTEM

WITH RED BLOOD.

ARTICLE FIRST.

GENERAL REMARKS UPON THE CIRCULATION.

ALL authors have considered the circulation in the same way, since the celebrated discovery of Harvey. They have divided this function into two; one has been called the great circulation, the other, the small or pulmonary. The heart, being between the two, is their common centre. But in presenting in this point of view the course of the blood, it is difficult at first sight to perceive the general object of its course in our organs. The method in which I explain in my lectures this important phenomenon of the living economy, appears to me infinitely better calculated to give a great idea of it.

I. *Division of the circulation.*

I divide the circulation also into two; one carries the blood from the lungs to all the parts; the other brings it from all parts to the lungs. The first is the circulation of red blood, the second that of black.

Circulation of red blood.

The circulation of the red blood commences in the capillary system of the lungs, where the blood acquires, by the mixture of the principles that it draws from the air,* the peculiar character that distinguishes it from the black blood. From this system it passes into the first divisions, then into the trunks of the pulmonary veins; these pour it into the left auricle of the heart, which transmits it to the ventricle, and this drives it into the arterial system; this spreads it into the general capillary system, which may be truly considered as the termination of its course. The red blood is then constantly carried from the capillary system of the lungs to the general capillary system. The cavities that contain it are all lined with a continuous membrane; this membrane spread upon the pulmonary veins, upon the left cavities of the heart and upon the whole arterial system, may be considered as a general and continuous canal, the exterior of which is strengthened in the pulmonary veins by a loose membrane, in the heart by a fleshy surface, which is delicate in the auricle, thick in the ventricle, and in the arterial system by a fibrous layer of a peculiar nature. In these varieties of the organs that are thus added to it without, this membrane remains every where nearly the same, as we shall see.

Circulation of the black blood.

The circulation of the black blood is performed in a manner the reverse of the preceding. It begins in the

* It may be remarked, that this work was published at a time when the theory of the oxygenation of the blood was universally considered as explaining in a satisfactory manner the change that is effected in the colour of the blood by the lungs. The experiments of Allen, Pepys, and others, and the Treatises of Ellis, have proved to the satisfaction of most physiologists of the present day, that this change in the colour is not owing to the absorption of oxygen by the blood, but to the extrication of carbon from it. *Tr.*

general capillary system; it is in this system, that its blood takes the peculiar character that distinguishes it from the preceding; it is here that it is formed, by the subtraction probably of the principles of the air that it acquired by terminating its course in the lungs. From this general capillary system, it enters the veins which transmit it to the right cavities of the heart, which send it by the pulmonary artery, to the capillary system of the lungs. This system is its real termination, as it is the commencement of the circulation of the red blood. A general membrane, every where continued, lines the whole course of the black blood, and forms for it also a general and continuous canal, in which it is constantly carried from all parts to the interior of the lungs. At the exterior of this great canal, nature has placed a loose membrane in the veins, fleshy fibres in the heart, and a peculiar fibrous texture in the pulmonary artery; but, like the preceding canal, it remains always nearly uniform, notwithstanding this difference of organs to which it is united externally. It is by the folds of this membrane in the veins that the valves are formed. It contributes to form all those of the right side of the heart, whose cavities it lines, as the preceding enters into the composition of the valves of the left side, which borrows from it the membrane that lines it.

Difference of the two circulations.

From the general idea that I have given of the two circulations, it is evident that they are perfectly independent of each other, except at their origin and termination, where the red and black blood are alternately transformed into each other, and communicate for this purpose by the capillary vessels. In their whole course they are entirely separate. Though the two portions of the heart are united in one single organ, they may however be considered as uniformly independent in their action.

There are truly two hearts, a right and a left. Both would be able perhaps to perform their functions as well if they were separate, as they now do united. When the foramen ovale remains open after birth, I have proved elsewhere that such is the arrangement of the two folds between which it is found, that the black blood cannot communicate with the red, and that the two hearts should equally be considered independent, at least as it respects the course of the blood. This entire separation of the two circulations is one of their most striking characters; it alone proves how much preferable the point of view in which I have presented the circulation, is to that which divides it into great and small, which are evidently confounded and identified.

From what has been said, it appears that the origin and termination of each circulation take place in the two capillary systems, which are, if we may so say, the limits between which the two kinds of blood move. The lungs alone correspond in this respect, with all the parts. Their capillary system is in opposition to that of all the other organs, if we except the parts from which the blood of the vena porta goes. Each capillary system then is at the same time an origin and termination. The pulmonary is the origin of the circulation of the red blood, and the termination of that of the black. The general gives to the red blood its termination, and to the black blood its origin. Observe that this is a great character that distinguishes the two circulations. In fact, the blood not only takes an opposite course at the place where they finish and at that where they begin; but its nature changes also entirely, and in this respect the two capillary systems, pulmonary and general, present to us the most important phenomena of the living economy, viz. the first, the transformation of black blood into red, the second, that of red blood into black.

There are evidently three things to be examined with regard to each of the circulations, 1st. the origin; 2d. the course; 3d. the termination of each kind of blood. In the origin and termination, there is on one hand the mechanical phenomena of circulation, on the other the phenomena of the transformation of the blood. In the course of this fluid there is only the mechanical phenomena of the circulation to be observed.

General mechanical phenomena of the two circulations.

By examining these phenomena in a general manner, we see, 1st. that the red blood going from the lungs, is formed into larger and less numerous columns, as it approaches the cavities of the heart; that it is in the greatest masses in these cavities, and that from them to the capillary system, it is continually dividing into smaller columns; 2d. that the black blood going from the general capillary system, is formed into columns larger and less frequent, as it approaches the right cavities of the heart; that these cavities contain the greatest quantity of it, and that from them to the lungs, it is successively divided into smaller columns.

The two kinds of blood circulate then on the two sides in branches that diminish as they go from the heart, and increase as they approach it. Represent to yourself for each of the two circulations two trees united at their trunks, sending their branches, one of them to the lungs, the other to all the parts. Each of the two parts of the heart is between these trunks, which it serves to unite, so as to form a general canal of which we have spoken.

Authors have commonly considered the arteries and veins as forming, each by their assemblage, a cone, the base of which is at all the parts, and the apex at the heart. This manner of describing them arises from this, that the sum of the branches is greater in diameter, than that of the trunks from which they arise; now in adopt-

ing this idea, it is evident that each half of the heart is at the summit of two cones, which would be united without it. The pulmonary veins represent one, and the aorta the other for the red blood; for the black blood, there is on one part the venæ cavæ and coronary veins, on the other, the pulmonary artery, which form the two cones. In each circulation, one of these cones is remarkable for its small size; it is that of the lungs; the other for its great extent; it is that of all the parts.

Placed between these two cones, each part of the heart should be considered as an agent of impulse which hastens the course of the blood, on one hand towards all the parts, on the other towards the lungs. In fact, if in each circulation these two cones communicate by their apex, it is evident that the parietes of the vessels that compose them would be insufficient to maintain the motion, from the base of one to the base of the other; that is to say from the general capillary system to that of the lungs, and reciprocally from that of the lungs to the general one. The course is manifestly too long, and the vital forces of the vascular parietes not sufficient to admit of this; hence the necessity of the heart.

This consequence leads to another, which is this. As the red blood has a greater extent to go over from the heart to the general capillary system, than the black blood has from the heart to the pulmonary capillary system, it is necessary that the portion of this organ belonging to the first kind of blood, should be endowed with a greater force than that destined to support the motion of the latter. Nature has effected this object by composing the ventricle with red blood of fibres much stronger than those of that of black blood. As to the auricles, as they only receive the blood and transmit it to the ventricles, their thickness is nearly uniform.

From this we see, 1st. that the part the heart performs in the two circulations, is absolutely relative to the me-

chanical phenomena of the course of the blood, and that, if it has any influence upon the composition, it can only be by the internal motion it communicates to it; 2d. that if the course of the two circulations, of black blood and red, was of less extent, they might do without this intermediate agent of impulse. This is precisely what happens in the system of abdominal black blood, the two trees of which distributing their branches, one to the gastric viscera, the other to the liver, unite by their trunk in what is called the sinus of the vena porta, which occupies exactly the place of the heart in the great system of black blood and in that of red.

It is then possible to conceive, 1st. how the heart may fail; of this we have many examples, in which the two great circulating systems resemble in a certain degree, the abdominal; 2d. how the blood can oscillate from one capillary system to the other, during a considerable time, though the heart, weak, enfeebled, and even in part disorganized, can hardly any longer accelerate the course of this fluid; 3d. how, this organ having entirely suspended its pulsation in syncope, asphyxia, &c. there is still an oscillation, a real progression of the blood from one capillary system to the other, so that if an artery or vein is then opened, it flows a little at the opening. Certainly this oscillation is very weak; it cannot last a long time; but we cannot deny that it exists without the influence of the heart, since the black blood is carried without the agent of impulse, from the intestines to the liver; hence it follows that the cessation of the pulsation of the heart is not a proof of the want of motion in the blood, as some authors have thought. 4th. We know that in many animals of the lower classes, there is no heart, though there are distinct vessels and circulating fluids.

The importance of the part that the heart enjoys in the animal economy is only in relation to the general impulse that it communicates to all the organs and the con-

stant excitement in which it keeps them by this impulse. It does not send to them the materials of secretion, of exhalation and of nutrition; it only in this respect transmits what it receives from the lungs.

II. *Reflections upon the general uses of the circulation.*

This leads us to some reflections upon the general differences of the uses of the two circulations; differences which prove the necessity of presenting the single function that results from them in the view in which I have placed it, and not in that in use in the treatises on physiology. The following are the differences.

General uses of the circulation of the red blood.

It is the circulation of the red blood that alone furnishes the matter of secretions, except that of the bile, a fluid which however deserves a further examination. It is from this circulation that the serous, cellular, cutaneous, medullary exhalants, &c. draw the fluids that they transmit upon their respective surfaces. All the vessels that carry the matter of nutrition of the organs are also continuous with the arteries and consequently their fluids come from the red blood. In the organs even in which the black blood goes, as in the lungs and the liver, there are vessels with red blood evidently for the purposes of nutrition. It is the red blood that communicates to the organs of the whole body that general agitation which is necessary to their functions, an agitation so evident in the brain. The circulation of red blood is then the most important; it is that, whence are derived the great phenomena of the economy.

General uses of the circulation of black blood.

The circulation of the black blood, on the contrary, having no connexion with any of the functions, seems only destined to repair, if we may so say, the losses the

blood has sustained in the preceding one. Observe in fact that a considerable part of the red blood is expended in the exhalations, secretions and nutrition. The principles it borrowed in the lungs and which gave it a vermilion colour, have been left in the general capillary system. It is necessary that the black blood should receive what the other has lost; now a variety of substances enters the great canal that contains it. These substances are internal or external. 1st. The great trunks of the absorbents constantly pour in the lymph of the cellular texture and of the serous surfaces, the residue of the nutrition of all the organs, the super-abundant fat, synovia and marrow. All that which is to be thrown from within out, is first poured into the black blood. 2d. All that which enters in from without, is also received by it. The chyle, the product of digestion, is at first uniformly carried into the general canal, in which it circulates. In the second place, it is with it that are mixed the substances of the air, which pass through the lungs in the act of respiration. In fine, when cutaneous or mucons absorptions take place, the black blood is always the first that receives the product of them.

It follows from this, that the circulation of black blood is, if we may so say, a general reservoir in which is poured in the first place all that is to go out of the body, and all that is to enter it.

In this last respect, it performs an essential part in diseases; in fact it is undeniable, 1st. that deleterious substances may be introduced with the chyle into the economy, and produce ravages there more or less evident in circulating with our fluids. For this, it is sufficient that the organic sensibility of the chylous vessels should be changed; then they admit what before they rejected, as the glands by changes in their organic sensibility, often secrete fluids that are usually foreign to them. 2d. We shall prove in the article upon the cuta-

neous system, that it is oftentimes the seat of the absorption of deleterious substances. 3d. We cannot doubt that besides the principles that colour the blood, there often passes through the lungs deleterious miasmata which produce diseases, as my experiments upon asphyxia have proved. The intestines, the lungs and the skin are then a triple gate open, in many cases, to different morbific causes; now these causes that enter thus into the economy are all received in the first place in the black blood; it is not until afterwards that they pass into the red blood.

An evident proof of this assertion is this, that we produce phenomena exactly analogous to those which result from them, by pouring artificially into the black blood those substances that are introduced in a natural way. Thus when a purgative or emetic infusion is introduced into the veins, alvine evacuations or vomiting ensue, precisely as when the substances of these infusions are introduced by friction upon the skin. The experiments of many physiologists leave no doubt upon this point. I am convinced that it is possible to give to animals artificial diseases, by making different substances infused into their veins circulate with the blood. I shall speak of these attempts in the article upon the glandular system. It is sufficient for me to mention them here, in order to prove that the black blood is a general reservoir in which many substances can enter, either naturally, or accidentally, and afterwards disturb the functions by passing into the whole circulating mass. The humoral pathology has undoubtedly been exaggerated, but it has still real foundations, and in many cases we cannot deny, but that every thing arises from the disorders of the humours.

Let us conclude from all that has hitherto been said, 1st .that the essential part which the circulation of the black blood performs in the economy, is to introduce into this blood different new substances; 2d. that that of the system of red blood is to expend on the contrary, the

principles that constitute it. One is constantly increasing, the other diminishing; to give is the attribute of one, to receive is that of the other. This sketch, which is perfectly true, and founded upon the most simple observation, appears to me very proper to establish an evident demarcation between the two divisions that I have adopted for the general circulation.

Health supposes a perfect equilibrium between the losses the red blood experiences, and the acquisitions the black blood makes. Whenever this equilibrium is destroyed, there is disease. If the black blood receives more than the red blood expends, plethora follows. That which is called the poverty of the humours, is manifest when more substances go from the red blood than enter the black.

These are I think sufficient characteristic attributes of the two great divisions of the general circulation, to justify the point of view different from other authors, in which I present this important function of the animal economy.

ARTICLE SECOND.

SITUATION, FORMS, AND GENERAL ARRANGEMENT OF THE VASCULAR SYSTEM OF RED BLOOD.

From the general idea that we have given of the two vascular systems, we should form the following of the position in the economy of that with red blood.

1st. The capillary system of the lungs gives rise to many minute ramifications, which soon unite into small branches, then into larger ones, and finally into four great trunks, two for each lung. These trunks open into the left auricle towards its superior part. 2d. This, distinguished

from the right by having fewer fleshy columns, by its smaller size, by the greater elongation of its appendix, which is narrower than that of the other, &c. communicates by an oval opening furnished with valves, with the left ventricle, the thickness of whose parietes, the arrangement of the fleshy columns, &c. distinguish it from the right. 3d. From this ventricle goes the aorta, the common trunk whence arise all those that carry red blood to all the parts, where they terminate in the general capillary system.

The first tree of the system of red blood, the trunk of the second and the heart that serves to unite them, are found then concentrated in the cavity of the thorax, whilst the branches of the second trunk are distributed among all the organs of the economy, and even to all its extremities.

It is nearly between the superior third of the body and the inferior, that is found the agent of impulse of the red blood, or the heart. This position is important; it places under a more immediate influence of this viscus, the superior parts, the head especially, all of whose organs, and particularly the brain, require inevitably a very active and habitual excitement from the blood, in order to keep their functions in permanent activity. Thus observe, that in the gangrene of old people, and the affections that arise from the blood not being driven with sufficient force to all the parts, it is the extremity of the foot that is first affected, and that of the head and the hands become much later the seat of mortification. In general, there are many differences between the phenomena that take place in the superior parts, and those that happen in the inferior. We shall see in the dermoid system, that the portion of the general capillary system which belongs to the first, is penetrated with blood with infinitely more ease, than the portion belonging to the inferior parts, as asphyxia, apoplexy, submersion, different cutaneous erup-

tions, injections even prove, which in young subjects blacken rather the face than the inferior parts; now this difference arises evidently from the relation of position of the superior and inferior parts with the heart.

We have no general remarks to offer here upon the first tree and upon the agent of impulse of the circulation of red blood. In fact, the remarks belonging to the lungs and the heart will be given in the Descriptive Anatomy. It is then especially the second or arterial tree, whose distribution is now to occupy us. It is necessary in this article to examine the origin, course and termination of it.

I. *Origin of the Arteries.*

This article comprehends the origin of the aorta at the left ventricle, that of the trunks which arise from it, then that of the branches, the smaller ones and the minute ramifications that go from them.

Origin of the Aorta.

Most authors have described inaccurately the manner of the union of this great arterial trunk with the heart. This is the manner; the internal membrane of the heart with red blood, after having lined its ventricle, approaches the opening of the aorta, is attached there, forms by its folds the three semi-lunar valves, and stretching afterwards into the artery, covers it in its whole extent. It is this internal membrane that forms the union of the artery with the heart. The peculiar or fibrous membrane is not identified with the fibres of the heart. Its extremity is cut into three semi-circular festoons, which correspond with the semi-lunar valves that they support. These festoons do not extend to the fleshy fibres; there is between them and these fibres a space of two or three lines that the internal membrane alone covers. Between them and consequently between the valves, we perceive three little empty triangular spaces, covered by the membrane

also. To distinguish this structure clearly, the origin of the aorta must be dissected well from without, and stripped entirely of the fatty texture that surrounds it. Then by cutting this artery and the ventricle, and by examining when held up to the light the union of one with the other, after having first removed the valves, we distinguish very well by the transparency of the internal membrane and the opacity of the three festoons that commence the aorta, the arrangement that I have just pointed out. It follows from this, that if the artery is accurately dissected on its exterior, and we detach from below upwards the internal membrane that forms the great canal of the circulation of the red blood, the artery is entirely separated from the heart. This entire separation of the fibres of the aorta from those of the heart, would alone be a strong presumption that their nature is not the same if many other considerations did not prove it in the most evident manner.

Origin of the trunks, branches, smaller branches, &c.

Arising thus from the left ventricle, the aorta divides almost immediately into two branches, one ascending goes to the neck, head and superior extremities; the other descending to the chest, abdomen and lower extremities. The first being very soon subdivided into four principal trunks, differs in this respect from the second, which forms for a long time one trunk only. The latter having to go over a much greater distance than the other, preserves with more certainty by this arrangement the whole of the motion that is given to the blood by the heart; this does not prevent, however, owing to the less distance, the impulse from being more sensibly felt by the superior than the inferior organs, as I have said above. At the superior part of the pelvis, the aorta divides into two secondary trunks. Soon after, subdivisions begin under the name of branches, which are afterwards multiplied under that of ramifications, &c.

Mathematical anatomists have exaggerated the number of the arterial sub-divisions. Many have thought there were a hundred to one artery; Haller reduced the number to twenty, and even less. To ascertain what is really the case, it is necessary to take the arteries at their origin, and follow their course under a serous membrane, the peritoneum for example, where they are every where very apparent; it will be seen in this way, that the sub-divisions are not more numerous than is stated by Haller; I have frequently satisfied myself of this. Besides, the inspection of a living animal whose abdomen is opened, is almost the only means that can be employed without danger of mistake. Injections when too coarse do not fill all the branches; when too fine, they pass into the exhalant vessels, and communicate to the whole serous surface a colour that is not natural to it. It is almost impossible to ascertain by injections, the precise point of the natural circulation. To be convinced of this, inject a dog and open the abdomen of another of the same size; you will see uniformly in one more or less vessels injected, than are seen in the other filled with blood. I frequently performed this experiment, at the time I was engaged in demonstrating the insufficiency of injections, either fine or coarse, to show the quantity of blood in any part.

When they divide, the arteries form among themselves very different angles. Sometimes right angles, as at the middle intercostals; sometimes obtuse, which is more rare, as at the superior intercostals; most commonly they are acute, particularly in the extremities. The origin of the spermatic artery is an instance of the extreme of this last kind of origin.

We observe in general, that wherever there are two divisions, one is larger than the other. The largest follows the original direction of the principal trunk, from which the other is more or less separated. In the inte-

rior of the artery, an eminence formed by the fold of the internal membrane, corresponds with the angle entering from without, and breaking the column of the blood, favours the change of its course. This eminence presents an arrangement, that is very variable, which is owing to the angle of origin. 1st. If the angle is a right one, the eminence has a circular arrangement and is equally evident in the whole circumference. 2d. If the angle is acute, as at the mesenteric, then this eminence is very evident between the branch that arises and the continuation of the trunk; it forms even a kind of semi-circular spur or projection, but between the trunk itself and the branch that arises from it, the union of which forms an obtuse angle, this eminence is less conspicuous. The more obtuse the angle is, and consequently the more opposed it is to acute, the less sensible is this second eminence; it has like the other a semi-circular form, and makes by its union with it a whole circle which is oblique; so that the portion of the circle formed by this second eminence is nearer the heart than that made by the other. 3d. If the angle of origin is obtuse, and consequently that formed by the branch with the continuation of the trunk is obtuse, things are then arranged in an inverse manner. There is at the mouth of the artery an oblique circle, the prominent half of which is nearest the heart.

The origin of the arterial trunks is generally pretty uniform; but that of the branches is so variable, that hardly any two subjects have the same arrangement, in this respect. Take for example the hypogastric; it would be impossible to form the least idea of its branches, if, neglecting the manner they separate from each other, you paid attention only to their course and distribution. These numberless varieties in the forms, are a remarkable character in organic life to which the arteries belong. This character must be placed at the side of the constant irregularity of the arteries. There is no symmetry in

their general distribution, as in the distribution of the nerves of animal life. Those even of the extremities, that correspond, differ frequently in their mode of origin and the course of their branches.

The branches, smaller branches, &c. arise at distances very near each other. There is hardly any, except the carotid, internal iliac, &c. that runs a considerable course without furnishing some. Thus experiments in which it is necessary to introduce tubes into arteries, to open them, &c. can scarcely be made except upon the first of these, they are prevented in others by divisions that arise from them and hinder us from raising the artery to any considerable extent.

The origin of the arterial trunks, branches, smaller branches and ramifications, does not take place in a gradual and necessarily successive manner. Thus the smaller branches, and the ramifications even, arise equally from trunks and branches; for example, the bronchial, thymic arteries, &c. go from the aorta, and yet they are not so large as most of the divisions of the tibial, which is itself a third division of the aorta.

II. *Course of the arteries.*

In their course the arteries present differences according as we examine, the trunks, the branches and smaller branches.

Course of the trunks and branches.

The trunks are the first divisions continuous with the two great portions of the aorta; such are above, the internal and external carotids, the subclavians, &c.; below, the iliacs, the hypogastrics, &c. Generally they are situated in broad interstices, that contain much cellular texture, as in the groin, the axilla, the neck, the sides of the pelvis, &c. By dividing they form branches that are received into smaller and narrower interstices, and

are consequently more exposed to the influence of the neighbouring organs. Both of them are covered almost every where by a thickness of parts that protects them from external injury. Besides this protection that the neighbouring parts and particularly the muscles afford them, they accelerate also the circulation of the blood, and reciprocally the motion of the arterial trunks gives to the neighbouring organs and even to the whole limb, a sensible motion, an agitation that supports its vital energy. This agitation, which it is often difficult to perceive, sometimes becomes very evident upon mere inspection. When the elbow is rested upon the table, and a body of considerable length held in the hand, its extremity is seen to vaccillate, to rise and fall a little at each pulsation. If the legs are crost, being first bent upon the thighs, a spontaneous rising is noticed in that which is supported. To this we must refer also the cerebral motion, that which is communicated to tumours that are situated over a great artery, &c. &c.

The trunks and the branches are accompanied by veins, and surrounded in general with a large quantity of fat, a circumstance that has been considered favourable to the opinion of those who think that this fluid is exhaled by the pores of the arteries. We have already said what should be thought of this opinion.

The direction varies in the trunks and the branches. Usually straight in the trunks, as in the carotids, the internal and abdominal iliacs, it renders the circulation less evident. When these trunks are exposed in a living animal, we do not see any kind of locomotion there, as we do when the curves are great. There is however some exception to this rule as it respects the direction of the trunks; the arch of the aorta is an example of it, so is the internal carotid, which has numerous curves, which are thought incorrectly, to be necessary to prevent the impetus of the blood from producing derangement in the deli-

cate substance of the brain. More tortuous in the branches, this direction occasions the arterial locomotion that constitutes almost exclusively the pulse, according to many physicians.

Course of the smaller branches, ramifications, &c.

Whilst the trunks occupy the large interstices that are left between several organs, and the branches the smaller ones that separate particular organs, the smaller branches are found in the interior of these same organs, without, however, entering into their intimate structure. Thus in the muscles, they are interposed between their fibres; in the brain, in the circumvolutions; in the glands, between the lobes that form them, &c. By them, an internal motion communicated to the whole organ, facilitates its functions by supporting its partial activity, as the motion of which I spoke above, supports the general activity of the part. Besides, the sudden cessation of life, when the blood ceases to agitate the brain, proves the immediate connexion between this internal motion and its energy. Thus we observe that life is much more active wherever the arteries are numerous, as in the muscles, the skin, the mucous surfaces, &c.; whilst on the contrary its phenomena are weaker and more obscure in the less vascular organs, as in the tendons, the cartilages, the bones and the other white parts.

In the smaller branches, the windings are much more evident than in the branches. Injections make them very conspicuous, especially in the brain; but as they depend principally upon the cellular texture they disappear in part, if we separate from it the vessels of all the parts. Do these windings diminish the rapidity of the circulation, and does the straightness of the arteries increase this rapidity as much as physiologists suppose? I think they have exaggerated the effects of the direction of the arteries; the following are proofs of it. 1st. If in

living animals we expose the hollow organs, as the stomach, intestines, &c. alternately in a state of fulness and in that of vacuity, I have observed that the circulation is almost equally rapid in both cases, though fulness renders almost straight the vessels of these organs, and that emptiness, by forcing them to wrinkle, increases their curves. 2d. I have opened the carotid artery of a dog, and having observed the force with which the blood is thrown out, I have also opened both sides of the thorax; immediately the lungs are collapsed and consequently the windings of their vessels increased; notwithstanding this no diminution in the force with which the blood escapes from the artery, after having gone through the lungs is immediately sensible. It is only gradually that the force is destroyed by the influence of causes, that it is not my object to examine. 3d. If in another animal, an artery being open, we open also the wind pipe, and by a syringe affixed to the opening suddenly exhaust all the air the lungs contain, this organ is immediately reduced to a very small size; the vessels become much bent, and yet I have observed in this case that the blood goes from the open artery with as much force as before, for a considerable time. 4th. Finally, after having opened the abdomen of a living animal, I have alternately contracted and stretched the mesentery, whose numerous arteries had been first opened; no difference is discoverable in the force with which the blood is thrown out, in either case.

Let us conclude from these experiments, that the influence of the direction of the arteries upon the course of the blood, is much less than is commonly thought, and that all the calculations of mathematical physicians upon the delay of the blood from this cause, rest upon unsubstantial foundations. There is no doubt that when the fore arm is strongly bent, the pulse is weakened, stops even, and it is essential when we feel the pulse that the arm should be extended; but this phenomenon does

not depend upon the angle the artery forms; it arises from this, that the muscles that press it, contract its caliber and even obliterate it. This is so true, that the different curves of the internal carotid are much more evident than the single curve that the brachial then forms, and yet the circulation is performed there very well. Besides, open an intercostal artery which has but few curves, the force with which the blood will be thrown out is not stronger than it would be from the radial, &c. If the whole arterial system was empty and the blood going from the heart filled it successively, as this fluid would strike against the arterial curvatures, it would undoubtedly experience some delay. It is on this account that in our injections a tortuous artery is slower in filling; as the spermatic for example often remains empty. But in a number of tubes full of fluid, it is wholly different; the impulse received at the beginning of them is suddenly propagated into all the cavities that form them, and not by a successive progression, as I shall say hereafter.

The arterial curvatures are adapted to the different states in which the organs may be found. We see them very evident in those which are subject to an alternate dilatation and contraction, for example in the intestines, the lips, and the whole face. In the fœtus, when the testicle is in the abdomen, the artery is very tortuous. When this gland descends, the artery untwists and takes the straight course it has in the adult. In the motions of the womb, the bladder, the pharynx, the tongue, &c. these curvatures perform an important part in the preservation of these organs. In the fractures of the lower jaw, they prevent the rupture of the artery that traverses this bone, a rupture which the displacing of the bone would produce without them. By them the arterial system is preserved unhurt in the violent and oftentimes forced motions that the limbs perform.

The flexibility of the arteries would be insufficient for these motions; in fact, when an artery is extended longitudinally, its diameter is diminished. By accommodating themselves to the motions of our parts, the vessels would impede then the circulation, because there would be less space for the blood to move in. Hence why the arteries of all the parts subject to alternate dilatations and contractions, being uniformly tortuous, can without the aid of their extensibility, have very different degrees of extent. I would remark upon this subject that the locomotion of the arteries, observed by Veitbrecht, is far more evident at the time of the contraction of the hollow organs, or of the flexion of the limbs, than during the dilatation of the one or the extension of the others. I have invariably made this remark upon living animals. We can by emptying or distending the intestines, the stomach, the bladder, &c. make their arteries beat more or less strong, &c. &c.

Anastomoses of the arteries in their course.

Anastomosis is the union of many branches, which mingle the columns of blood that each brings. There are two kinds of anastomoses; sometimes two equal trunks unite, sometimes a small trunk is joined to a large one.

The first has three varieties. 1st. Two equal trunks sometimes unite at an acute angle, and form but one; it is thus that the ductus arteriosus and aorta are blended together in the fœtus; that the two vertebrals produce the basilary trunks, &c. &c. 2d. Two trunks communicate at certain places by a transverse branch; such are the two anterior cerebral, before they go between the hemispheres. 3d. Two trunks unite and form an arch; this is the case with the mesenteric; then branches arise from the convexity of this arch. We see then that there are three kinds of anastomoses between equal branches; one

of these is that in which two columns of blood are united together and take a direction between the two first; another in which two columns follow their first direction, and only communicate with each other; finally in the last, two columns meet each other by their extremities, in an opposite direction, and the blood escapes afterwards by secondary vessels.

The second kind of anastomoses is that of considerable branches with smaller ones; it is extremely frequent, especially in the extremities; it has no varieties.

It is almost always in regions remote from the heart that anastomoses are met with. We find scarcely any in the trunks that arise from the aorta. They begin to be more frequent in the branches, as in the mesenteric, the cerebral, &c. The more the smaller branches are subdivided, the more numerous are the anastomoses. In the last ramifications they are so numerous that they form an inextricable network. This arrangement is calculated to facilitate the circulation, which the anastomoses favour in places, where the motion of the blood is liable to experience obstacles. It is on this account that in the cavities in which the influence of the neighbouring parts upon the motion is less sensible, the anastomoses become more frequent, as in the brain, the abdomen, &c.; whilst they are more rare in the muscular interstices of the extremities, &c. It is not then a tree with distinct branches that forms the arterial system, but a tree all the parts of which communicate together, more frequently as they are the further removed from the origin.

The principal object of the anastomoses, that of obviating the obstacles the blood experiences in its course, is fulfilled in many cases. Thus, after the ligature of a wounded artery or one with an aneurism, after the spontaneous obliteration of one of these vessels, we see the anastomoses between the fine branches, above and below this obliteration or this ligature, continue the circulation

in the part. These collateral vessels then increase often in size; but more frequently still, the course of the blood is supported almost entirely by the capillary vessels.

Anastomoses suppose then the vitality of the arteries. It is because these vessels are not inert, but act themselves upon the fluid they contain, that the circulating phenomena are subject to so many variations; that oftentimes, and especially by the influence of the passions, the spasm of their extremities, principally of the capillaries, obliges the blood to flow back, a reflux which is favoured by the anastomoses. This reflux is necessary also in inflammations, in the different engorgements of our organs, &c. How would the circulation be able to go on, if all the small branches went to their respective destinations, without communicating among themselves? Would not the least embarrassment occasion a troublesome stagnation there?

I would remark upon this subject that the anastomoses furnish the first proof of a truth which we shall soon demonstrate more in detail, viz. that in the great trunks, the blood is especially influenced by the heart, and that in the capillaries, it is exclusively by the vascular parietes. In fact it is because the vitality of the arteries is every thing for the motion of the last subdivisions, that the least alterations that they experience give rise to many engorgements that inevitably require anastomoses, which are extremely numerous at the end of the arterial tree. On the other hand, the vitality of the trunks having scarcely any influence upon the blood, it experiences but few obstacles in passing through them; there is less need then of anastomoses, which are in fact more rare there.

If the least cause, the least irritation produced spasm of the trunks, as they produce that of their last divisions, it would be necessary that they should communicate as frequently together. A fleshy texture in the great arte-

ries, and vital properties analogous to the involuntary muscles, would have required inevitably these numerous anastomoses, because a variety of causes influencing these kinds of muscles, they can at any moment increase unnaturally their contraction, diminish their caliber and embarrass the progress of the fluids that traverse them.

Forms of the Arteries in their course.

Many physicians of the present age have described each artery as forming a cone, the base of which is towards the heart, and the apex towards the extremities. If we examine a portion of it between the origin of two branches, whether after having injected it, or by cutting it perpendicularly when it is empty, or by measuring it when it is full of blood, we find it always cylindrical. Undoubtedly considered in its whole extent, it takes a conical form, the effect of its successive diminution by the branches it furnishes; but in this sense it is less a cone, than a series of cylinders successively joined to each other and always decreasing.

Considered in its general arrangement, the arterial system represents on the contrary, as I have said, a cone absolutely inverted, that is to say, having its base at all the parts and its apex at the heart; so that the aorta has a diameter less considerable in proportion, than that of the sum of all the branches. We have a proof of this by comparing a trunk with two branches that succeed it; these surpass it in diameter, and the relation being always the same in all the subdivisions, we conceive that the capacity of the arterial system goes uniformly increasing.

This relation of the trunks and the branches has been exaggerated however by mathematical physiologists, who attributed to the last over the first a predominance much greater than really existed. A cause of error upon this point may arise from measuring the arteries at their ex-

terior after having injected them; in fact, the caliber of the trunks is greater, in proportion to their parietes, than that of the branches separately examined; that is to say, other things being equal, the aorta has parietes thinner in proportion to its cavity, than the cubital artery; hence, without doubt, why aneurisms are rare in the branches, and frequent in the trunks, especially when the diseases arise from a local cause; for if they are the effect of a general disease, oftentimes the little arteries, the radial particularly, are also affected; I have already seen two examples of it. This observation upon the proportions of the arterial parietes proves the impossibility of judging of the relations of diameter between the two, at least by examining them in the interior.

Besides, these relations are necessarily very variable, according as the vital forces which vary themselves so much, increase or contract the caliber of the small arteries; and in this point of view, this examination cannot have the importance that was attached to it by the ancients, whose works are filled with calculations upon this point.

III. *Termination of the Arteries.*

After being divided, subdivided, and having the peculiarities we have just examined, the arteries terminate in the general capillary system. To point out where this system begins, and where the arteries end, would be very difficult. We can prove that there the blood ceases to be entirely under the influence of the heart, and circulates by the influence of the insensible organic contractility of the vascular parietes; but how can this line of demarcation be rendered evident to the eye?

Authors in treating of the termination of the arteries, have considered their continuity with the excretories, the exhalants, the veins, &c.; but it is evident that the general capillary system is between the arteries and these ves-

sels. Thus I shall treat of their origin in speaking of this system, which is spread in all the organs, but has essential differences according to the different systems, under the relation of its continuity with the arteries. In fact, 1st. there are systems in which these vessels are distributed in great quantity, and in which consequently the general capillary system contains much blood; such are the glandular, the mucous, the cutaneous, the animal and organic muscular, &c. 2d. Other systems receive but few arteries, as the osseous, the fibrous, the serous, &c. and consequently have but little blood in circulation in that portion of the general capillary system that belongs to them. 3d. Finally the pilous, epidermoid, cartilaginous systems, &c. destitute of arteries, contain only white fluids in the division of the general capillary system that has its seat in them.

ARTICLE THIRD.

ORGANIZATION OF THE VASCULAR SYSTEM WITH RED BLOOD.

I. *Textures peculiar to this organization.*

The red blood circulates, as I have said, in a membrane arranged in the shape of a great canal, variable in its form, extended from the pulmonary capillary system to the general one, and having every where the greatest analogy. At the exterior of this membrane, nature has added a fibrous coat for the arteries, fleshy fibres for the heart, and a peculiar membrane for the pulmonary veins. I shall speak here only of the arterial coat. The fibres of the heart and the membrane of the pulmonary veins will be examined, one in the organic muscular system, the other in the system with black blood. As to the internal membrane of the arteries, which is also that of the

whole system with red blood, we shall examine it in a general manner.

Peculiar Membrane of the Arteries.

This membrane is firm, compact, very apparent in the great arteries, less evident in the last divisions where it is insensibly lost. Its colour is usually every where the same. If the branches appear red in living animals, and the trunks yellowish, it arises only from the transparency of the one which allows the blood to be seen, and the opacity of the others. The colour of the arterial fibre is yellowish. However it assumes in certain cases a greyish appearance. I have often observed in arteries exposed to maceration, that it reddens in a very evident manner at the end of some days, or rather that it takes a rosy tinge, very analogous to that of the cartilages of the fœtus and of the fibro-cartilages of the adult, submitted to the same experiment. This result is however less uniform in the arteries than in those two systems, in which it is never absent. Sometimes the internal membrane reddens also, but never the external or cellular; on the contrary, the longer this remains in water the whiter it becomes. When the fibrous coat of the arteries has continued some time with this redness, it gradually loses it, if maceration is continued. This phenomenon is often more evident in the branches than in the trunks. For example, the arteries at the base of the cranium become red very frequently in the dead body, by remaining in the fluids with which this part is moistened. We see, in opening the cranium, this redness which does not belong to the blood left in the arterial cavities, as we may be easily convinced.

The thickness of the peculiar membrane of the arteries is very evident in the great trunks. It constantly diminishes; a circumstance that distinguishes it essentially from the internal membrane, which I have found almost as thick

in the tibial artery as in the aorta. It has been thought that in certain arteries, as in the cerebral, the fibrous coat is entirely wanting. There is no doubt that in the vertebral and internal carotid it is thinner in proportion than in equal trunks situated in the muscular interstices; but by examining attentively these arteries, I have clearly distinguished circular fibres in them. Has the thinness of their parietes an influence upon the sanguineous effusions, which are, as we know, so frequent in the brain? I cannot say. These effusions take place only in the capillaries, the trunks are never the seats of them; now it is impossible to examine these capillaries. I have sought in vain to ascertain by injections the vessels torn in apoplexy. Besides, this hemorrhage does not resemble that of the serous membranes; it is not an oozing through the exhalants of the ventricles; for these cavities are very rarely the only seat of it. Almost always these effusions take place even in the cerebral substance, generally nearer the posterior than the anterior lobe. The cerebellum is rarely affected by it. When the tuber annulare becomes so, there are often small partial effusions there, separated by medullary partitions that remain uninjured.

As to the arteries of the other parts of the body, their peculiar membrane presents generally a pretty uniform arrangement. It has appeared to me however, that in the interior of the viscera, of the liver, of the spleen, it is rather thinner than in the intermuscular spaces, and even than in the muscles.

This membrane is composed of very distinct fibres, adhering to each other, easily separated however, arranged in layers, in such a manner that after having raised the cellular covering, we can without difficulty separate these different layers from each other; it is this that has made many authors believe that the great arteries were composed of a great number of coats. The fibres that form these layers are circular or nearly so; the external ones appear

to be attached to the compact cellular texture that is contiguous. In fact, by raising this, a number more or less considerable adheres to it always in an intimate manner. As to the internal membrane, it does not appear to furnish any attachment; we raise it easily, without bringing with it any arterial fibres. The manner of the adhesion of these fibres with the compact neighbouring texture, appears to me to have great analogy with the origin of the organic muscular fibres, which are attached in a great number of places, to the sub-mucous texture.

When a branch arises from a trunk, the circular fibres of the last separate and form on each side a half ring, whence arises a complete one, which embraces the small rings formed by the circular fibres of the arising branch. These circular fibres go even to the eminence of the common membrane, which is seen within the arterial cavity and of which I have spoken; so that the whole thickness of the peculiar membrane serves as a support to their origin. But there is but little continuity between the two kinds of fibres. Those of the branch do not arise from those of the trunk; it is the internal membrane that serves to fix them together, as fibres of communication. Dissection shows easily these branches set at their origin in the ring which arises from the separation of the circular fibres. We remark this at the origin of the intercostals and lumbars upon the aorta, &c. When two trunks of an equal size go off, as the iliacs, the last circular fibres of the primitive trunk which they formed, interlace intimately with the origin of each of the two circular layers, that arise at the fork that separates this origin. Thus the last rings of the aorta cannot be separated from the first of each iliac.

There are no longitudinal fibres in the arteries.

What is the nature of the arterial fibre? Almost all anatomists have considered it the same with the muscular. But if we examine them attentively, it is easy to

be convinced of their differences. The want of red colour does not establish these differences, since in man even, some parts really muscular, as the intestines, want this colour. But the muscular texture is soft, loose and very extensible; the arterial texture on the contrary is firm and solid, breaks before it yields. We can observe this, by tying an artery tight. The two internal coats are cut; the cellular alone is not, though the ligature is immediately applied to it; we observe, by opening the artery, a section corresponding with the thread, exactly similar to what a cutting instrument would have made.

I have often repeated this experiment, pointed out by Desault, upon the dead body, and upon living animals; the result which is very uniform, explains the frequency of hemorrhages after the operation for aneurism. There is undoubtedly no texture so brittle, if I may use the word, as the arterial, none consequently less proper to be embraced by ligatures. Why is it that this should be the only one in which it is necessary to apply them? This phenomenon alone would distinguish the arterial texture from the muscular. In fact, the preceding experiment, made upon a portion of intestine in which the fibres are arranged like the arterial, would produce a flattening, an approximation of these fibres, but would not cut them.

Moreover compare the properties of texture of the arteries with those of the muscles; compare their vital properties, by examining the articles in which I treat of these properties; compare their development, and especially the different morbid alterations to which the two are subject, and you will see that there is not a single relation in which they have the least analogy. The aneurism of the heart and that of the arteries have nothing in common but the name. In one there is a rupture of the arterial fibres, a dilatation of the cellular coat; in the other an unnatural increase, a real development of muscular fibres which preserve their appearance and their properties.

Notwithstanding the ease with which the arterial fibres are broken in cases of aneurism, they enjoy in a natural state a very considerable degree of resistance and force; another character that distinguishes them from the fleshy texture. The following are the proofs of this resistance, which takes place both transversely and longitudinally. 1st. If we tie the carotid artery above, and drive a fluid afterwards into it, great force must be employed to break its texture. The same thing happens when we force in air instead of a liquid. Frequently the efforts of a man are insufficient to produce a rupture; thus the force of the heart can never cause it suddenly; so that the formation of aneurisms takes place only from the long continued action upon the arterial parietes; I doubt whether these tumours can be formed, without a previous alteration of the arterial texture, by the force of the impulse of the blood alone against the weak parietes of the arteries. 2d. the resistance of these parietes takes place longitudinally also. If we draw in a contrary direction, the two ends of an artery and of a muscle, we effect with more difficulty the rupture of the first, when the dead body is the subject of this comparative experiment. But upon the living the effect is opposite; the vessel yields to a very strong action made upon it; it would be necessary that this action should be incomparably greater to divide the muscle. This difference arises evidently from the vital properties of the latter, which in this case contracts violently, whilst the artery can make no further resistance than from the nature of its texture. Besides, this longitudinal resistance to distension is less than the lateral resistance opposed to the injection; experiments prove it, and it arises without doubt from this, that no fibre, in the first case, is found directly opposed to the effort.

This resistance of the arterial texture, so different from that of the venous, is a necessary consequence of the situation of the heart at the origin of the arteries. In fact,

this organ driving the blood with force into their tubes, should find there a force capable of resisting the greatest efforts of which it is susceptible, when its sensible organic contractility is raised to a high point. This is the great advantage of the arterial texture. What would become of the circulation and all the functions that depended upon it, if the least cause which increased the force of the blood could dilate the parietes of the arteries beyond the ordinary degree? It was necessary that their texture should render these parietes independent of the different degrees of motion of the fluid that circulates in them; whence it follows that a fleshy heart and resisting arteries are two things inevitably connected. If nature had doubled the energy of the heart, she would have doubled also the arterial resistance. On the other hand, they would have had but little resistance, if there had not been an agent of impulse at their origin; this is precisely what happens in the hepatic portion of the vena porta, which by its distribution is analogous to the arteries. Why is the pulmonary artery thinner and less resisting than the aorta? Because the right ventricle being less fleshy, is not capable of so great efforts.

From what has been said, it appears, that the external arterial membrane resembles the fibrous organs, which, as we shall see, are characterized by an extreme resistance. But if we observe on the other hand that this membrane can be broken, raised by layers and scales in dissection, that it is elastic and even dry, if I may so say, whilst the fibrous organs are compact, form a solid body, resisting, but softer and more elastic, we shall be convinced that this external membrane is exclusively peculiar to the arteries; that it has no relation with the other systems, but forms a distinct and separate texture in the economy. The structure with regular fibres, is the only circumstance that can, in my opinion, make us believe in the muscular nature of the arteries; but the ligaments

and tendons are fibrous also ; of what importance are the forms to the intimate nature ? Now, can we say that this nature is the same, when the physical properties, when the extensibility and contractility of texture, when the vital sensibility and contractility are different ?

Besides, the action of different re-agents upon the arterial texture, proves clearly how much it differs from the muscular. There are then general phenomena common to all the solids; but different peculiar phenomena that are distinctive. We may satisfy ourselves of this, by comparing the following article with that which corresponds with it in the muscular system.

Action of different agents upon the arterial texture.

The action of the air by drying the arteries gives them a colour of a reddish yellow, very deep and even blackish in the great trunks, more clear in the smaller ones. Thus dried, the arterial texture is almost as hard as the cartilages in the same state, extremely brittle, breaking in the great trunks with a crackling noise, that is not perceived in any other animal texture. It is especially in this preparation, that we see how much the cellular covering of the arteries differs from their peculiar texture. This covering remains pliable; it is whitish when raised up separately. Immersed again in water, the arteries assume in part their natural arrangement.

In drying, the arterial texture loses but very little of its thickness; this is a phenomenon that distinguishes it from most of the other textures. It arises from the small quantity of fluid that is contained between its layers, a circumstance that appears to be owing to the absence of the cellular texture. In opening the arterial layers, the kind of dryness they exhibit is remarkable, when compared with the moisture in which the muscular fibres are immersed.

Exposed wet among other organs to the action of the air, the arteries putrefy with great difficulty. Their texture resembles in this respect that of the cartilages, the fibro-cartilages, &c.; it is like them for some time almost incorruptible; when it is left to putrefy by itself, it gives out an odour much less fœtid than that of other textures; there appears to be less ammonia disengaged from it. The absence of fœtor is also very remarkable in the water in which the arteries have been macerated, entirely separated from every neighbouring texture. By comparing this water with that in which muscles have been macerated, the difference is striking. An evident proof of the resistance of the arteries to putrefaction and maceration, is what is observed in the viscera, which have been a long time macerated or which are putrid, as in the liver, the spleen, the kidnies, &c. In both cases, in the first especially, these viscera are reduced to a kind of pulp; the arteries however have preserved their texture still hard, amid this general softening. By removing carefully the putrid substance, we can follow them even to their final ramifications. This method of seeing the arteries is easy, whether they are filled by injection, or left empty. In the living animal, these vessels are also infinitely less susceptible of putrefaction than the skin, the cellular texture, &c. An artery often passes through a mortified part without undergoing any alteration from it; this is frequently seen in gun-shot wounds.

At the end of a period, very different according to the degree of temperature, the arterial texture yields finally to maceration and putrefaction. In the first case, it softens gradually without changing colour, loses the adhesion of its fibres, and is ultimately resolved into a pulp almost homogeneous and greyish. In the second case, it becomes greyish at first, then is reduced also to a pulp, and when all the fluid part is evaporated, there is left a kind of coal wholly different from that which remains

after the putrefaction of the muscles. In general, it requires much longer time to soften the arterial texture by maceration than by putrefaction; which shows the superiority of the action of the air over that of water, in the production of this phenomenon.

Exposed to the contact of caloric, the arterial texture curls up, contracts and exhibits the horny hardening in the highest degree. If the action of water is added to that of caloric, which produces boiling, the following is the result of it. 1st. Very little froth rises before ebullition, from the vessel that contains the arterial texture; we might say that this texture and the muscular present in this respect, two opposite phenomena in the economy; the small quantity of froth that arises from the first, is greyish. 2d. At the moment of ebullition, there is an evident horny hardening, less however than that of the nervous texture, more sensible in the direction of the diameters than in that of the axis; a hardening accompanying this horny hardening, and a yellowish tinge of the liquor. 3d. This state continues for half an hour or more, ebullition constantly going on. 4th. Successive softening; but at the same time a greyish tinge succeeding to the yellow colour; want of adhesion among the fibres, increasing as the ebullition goes on, so that they break with great ease. 5th. However prolonged may be the ebullition, the arterial texture is never reduced, like the fibrous, the cartilaginous, &c. to a gelatinous and yellowish pulp. The fibres remain as they are, in the same relation, with the same size, &c. The want of adhesion and the change of colour are almost the only phenomena they experience. 5th. The broth, produced by the boiling, is insipid and tasteless, a proof how few neutral salts the arterial texture contains.

The action of the concentrated acids curls this texture, afterwards softens it, finally dissolves it in the form of a pulp, yellowish by the nitric, and blackish by the sulphuric.

Most of the others have a less sensible action than these two. When they are diluted, there is no horny hardening at the moment the artery is immersed in them; but its texture is gradually softened, and can be broken with the least effort, as after boiling. It is never reduced to a fluid state, how long soever it may continue in the acid.

The alkalies, even the caustic, have but little action upon the arterial texture; immersed a long time in them, this texture remains almost untouched, loses but little by solution, cannot be broken as it can after being in the diluted acids, &c.

Membrane common to the system with Red Blood.

I call that the common membrane which lines the arteries, the left side of the heart and the pulmonary veins. It can be dissected with ease upon these two last organs. To separate it from the arteries, it is necessary to cut through by a very superficial circular section, the external fibrous layer, raise this layer by laminæ from below upwards; we come then to the internal membrane, which adheres but little to the preceding, and can be detached from it in the form of a canal, of very great extent. It is distinct from it, 1st. by its extreme tenuity, and the transparency that results from it; 2d. by its white colour; for it appears yellow only by being applied to the preceding; 3d. by the entire want of fibres. It is smooth and with a uniform texture like the serous membranes, which we may be convinced of by holding it up to the light. Besides, it differs essentially from these membranes by a kind of brittleness that characterizes it; it is broken and torn by the least effort. The whole resistance of the arteries resides in their fibrous coat.

It appears that this membrane, though every where connected, has however some differences of structure in

the different regions. 1st. It is evidently more delicate in the interior of the ventricle with red blood, than in the corresponding auricle and in the arteries. 2d. It yields in the heart and in the pulmonary veins, to dilatations much greater than those of which it is susceptible in the arteries, in which it would inevitably break, like the proper membrane, if the blood could produce as great differences of size in it, as it does in these organs. 3d. When we macerate the heart for some time, this internal membrane acquires in the auricle and upon the mitral valves, a very remarkable whiteness, and which is foreign to it in all the rest of its course. 4th. As to the action of the different agents, of the air, of water, of caloric, &c. it appears to me to be the same every where, and resembles precisely that upon the peculiar membrane. Only I have thought, that in the small arteries, the common membrane has the horny hardness more than this, which on this account wrinkles on the interior in different places, when a whole branch is immersed in boiling water; this does not take place in the great trunks.

It is evident from this, that though the common membrane of red blood, is every where continuous, it is not uniform in its structure; we shall have occasion to make an analogous observation for the different portions of the two general mucous surfaces.

The internal surface of this membrane is moistened in the dead body, by an unctuous fluid, that is found in greater or less quantity. Does this fluid exist in the living? does it serve to defend the arterial coat from the impression of the blood? It is difficult to determine. We know of no organ fitted to furnish it; it would arise from the exhalants, if its existence, as many authors have admitted, was real. It would be well to ascertain as to its existence, whether it was merely a transudation after death, analogous to that of the bile through the gall bladder, or the consequence of a little serum remaining in the

arteries after the expulsion of the blood. What makes me suspect so is, that these arteries being deprived of blood, contract intimate adhesions on their internal surface; which their fluid ought to prevent, as that of the mucous tubes does, which should they cease to transmit their respective substances, as the excrements for example, the secreted fluids, &c. would never be obliterated because of this fluid.

It appears then that it is the membrane itself, and not a fluid that escapes from it, which serves to protect the artery; it can, in this point of view, be considered in relation to the blood, as a kind of epidermis. It is this, which by its folds contributes especially to form the aortic and mitral valves, and the different eminences at the origin of the branches, smaller branches, &c. The external surface, feebly united to the other membrane as we have seen, has not an intermediate cellular one. Notwithstanding this slight adhesion, no means, boiling water, maceration, putrefaction, &c. can detach one of these membranes from the other, as takes place in the periosteum from the bone, which, are naturally much stronger united; it requires always the aid of dissection.

What is the nature of this common membrane? I am entirely ignorant; though with a different appearance it has the greatest analogy with the preceding coat, in its properties. We cannot class them in any system. They form a separate texture in the economy, a texture that has properties entirely distinct.

When we dry the common membrane of the arteries by itself, it is infinitely more pliable than the other. It remains transparent, the other does not. As to the phenomena of the other re-agents, except the horny hardening, they are nearly the same.

This membrane is remarkable, in all the organic systems, for the singular tendency it has of being ossified in old age. I have been able to satisfy myself, that out of

ten subjects, there are at least seven that have incrustations after the sixtieth year. These incrustations, having no connexion with the peculiar fibrous membrane, begin uniformly on the external surface of this, the most external part of which they attack; for there always remains over the incrustation a kind of pellicle that separates it from the blood, and which belongs to the membrane; the earthy substance is never immediately in contact with this fluid.

These incrustations do not follow any of the laws of ordinary ossification. The cartilaginous state rarely precedes them. The saline substance is deposited immediately upon the exterior of the common membrane by the exhalants. It is always in separate plates, more or less broad, that this exhalation is made; rarely the whole of the artery forms a solid continuous tube; so that the membranous portions remaining between the plates can be considered as serving for articular connexions, and that the arteries, thus ossified, are composed of many pieces moveable upon each other, and being able to a certain extent to adapt themselves to the circulating motion.

As long as these plates remain thin, the interior of the artery is as usual smooth and polished. But if many saline substances are deposited there, they then have a greater thickness and make a projection within. The fine pellicle that covers them and which is continued upon the artery, is broken; then they adhere only by their external surface to the peculiar membrane. Their circumference is unequal and rough. If there is a great number in the artery, the whole internal surface presents numerous asperities, produced by the rupture of this extremely fine layer of the common membrane that covers the osseous plates. This arrangement is particularly remarkable at the origin and even in the course of the aorta. I have noticed it frequently in the dissecting

rooms. Since I have practised medicine in the hospitals, I have already opened three or four subjects that have exhibited this arrangement, in which the heart was perfectly untouched, but who died however with most of the symptoms that accompany diseases of that organ. The rupture of the fine pellicle when the osseous plates become large, arises from the remarkable brittleness that we have observed in the common membrane, of which it is an appendage. I have never seen these osseous plates entirely detached, and become loose in the artery.

All the parts of the arterial system are subject to ossification. It appears as frequent in the branches as in the trunks. We know how common it is to find the radial ossified, in feeling the pulse of an old person. The ramifications appear to be less frequently the seat of these incrustations, which never take place in the capillary system; a circumstance that would induce me to believe that the common membrane of the arteries does not extend to this system, but that it changes gradually into a different texture.

It is not only in the arteries that the common membrane of the system with red blood is penetrated with saline substance; this often happens to it in the heart, especially in the aortic and mitral valves. It is more rare upon the internal surface of the left ventricle and auricle and the pulmonary veins. I have had however examples of these last. This general disposition to ossification in its whole course, proves that its nature is every where the same, and that notwithstanding the differences pointed out, I have had reason to consider it in an uniform manner, from the pulmonary capillary system to the general; for as I have already observed, an identity of diseases supposes an identity of nature. It is the frequency of ossifications of this membrane in the heart of old people, which renders extremely frequent the intermission of the pulse at that age. The ossification of the

origin of the aorta has an influence also upon the circulation, as I have ascertained; but that of the trunks, branches, &c. does not produce the least derangement.

The ossification of the common membrane of the system with red blood differs essentially from those that happen in other parts, in this, that it is, if we may so say, a natural phenomenon, whereas the others are accidental and often preceded by inflammation and engorgement. Thus these ossifications do not follow the progress of age; they happen in young people and in adults, as often as in old ones. Before old age, the ossifications of this membrane are observed also, but infinitely more rarely than at this age. The diseases of the heart which the ossification of the mitral valves accompanies and often alone constitutes, are a remarkable proof of this. A phenomenon has struck me many times upon this subject; such an ossification as an old man can live with very well, and which only makes his pulse intermittent, produces in the adult the most serious consequences. I have already opened many subjects, who had been affected with difficulty of breathing, frequent suffocation, cough, irregularity of the pulse, necessity of an erect position of the trunk, and in the later periods, infiltration, serous effusion in the thorax, spitting of blood, &c. and in whom I have found only ossification of the mitral valves, less than we see every day in the bodies of old people in our dissecting rooms. I confess that even this natural disposition to ossification in the common membrane of the system with red blood, had made me think that they had exaggerated a little the cases in which this ossification becomes, in the adult and even in the old man, when it is very strongly marked, the cause of that series of phenomena, whose assemblage forms the asthma of most physicians. But the practice of the Hôtel Dieu shows me every day, that these cases of ossifications, those of aneurisms and those of other organic affections of which the heart is the seat,

form a class of chronic diseases almost as numerous as that of the chronic diseases of the lungs, to which generally were referred all the diseases of the chest, before the time of Corvisart.

II. *Parts common to the organization of the Vascular System with Red Blood.*

Blood Vessels.

The parietes of the arteries contain secondary arteries destined to their nutrition. These arteries come usually from neighbouring branches, sometimes from the artery itself, whose capillary divisions terminate in the texture of its parietes. The heart exhibits this arrangement. At its exit, the aorta sends off the coronaries which are spread upon the texture of this organ and upon the origin of this artery itself. The bronchials furnish the parietes of the pulmonary veins. In the arterial texture, in which it is especially necessary to examine the little arteries, they wind at first in the cellular texture exterior to the artery, they ramify there in a thousand ways, send some divisions to the neighbouring organs, but furnish a great number that penetrate the peculiar membrane, are interposed between its layers, leave filaments there and terminate before they arrive at the internal membrane. I have never seen, either by injections, or by opening in a living animal an artery in which I had first stopt the course of the blood above and below, as for example, the carotid, I have never seen, I say, the little arteries penetrating even to this internal membrane. To distinguish well without injections, the vessels of the arteries, it is necessary to choose on one hand a great trunk like the aorta, and on the other to take this trunk in a young animal that has been killed for the purpose by asphyxia; all the little arteries then are perfectly injected with a very black blood. Examine the arteries of the fœtus,

especially if it has died by asphyxia at birth, you will be struck with the great abundance of blood vessels that its great arteries contain and which are sometimes as livid as in asphyxia.

The veins accompany every where the little arteries in the parietes of the arterial trunks, they follow nearly the same distribution. I have not seen them become varicose in the parietes of aneurismatic arteries, in as evident a manner, as in the tumours of many other textures of the animal economy.

Cellular Texture.

The arteries have around them two kinds of cellular texture; one, which is very external, loose, fatty, full of serum, with distinct layers, unites them to the neighbouring parts, favours their motions, is in no way distinct from the rest of the cellular system; the other, firm, compact, not fatty, filamentous and not lamellated, forms the first of their coats. We have spoken in treating of the cellular system, of this particular layer that covers the arteries, which authors commonly call the cellular coat, which the ancients called nervous, on account of its whiteness, and which, analogous in every respect to the sub-mucous, sub-excretory cellular texture, &c. differs essentially from the preceding, as it differs from that which is in the interior, around or in the interstices of the organs.

These two kinds of cellular texture, the last especially, contribute to support the folds of the arteries; as when we have carefully dissected the peculiar coat, these folds entirely disappear. However when they are on one hand strongly marked, and on the other, are not subject frequently to disappear in yielding to the elongation of the parts, as in the internal carotid in its canal, I have observed that the arterial fibres are accommodated to these folds; that the fibres are more numerous on the convex

side, than on the other, so that the thickness of the artery is exactly uniform, which it would not be without this inequality; for being more pressed on the concave side, these fibres would make the artery thicker at that place.

The cellular texture forms the first membrane of the arteries, and gives as we have seen insertions to the arterial fibres, but it does not extend into the interstices of these fibres; it is this that distinguishes essentially the layers of the arterial texture, from those of the muscular, venous textures, &c. I have never been able to discover the cellular texture there by any means that I could employ. Maceration, of which Haller has said so much, does not show any thing like it. When at the end of a very long time, the arteries finally yield to it, they exhibit only a kind of pulp, in which there is no cellular appearance.

In general, the resolution of the organs into cellular texture by maceration, exhibits a phenomenon much less extensive than is generally thought. It is the organic texture itself that forms the kind of pulp that is then obtained. As this texture varies in each system, the pulp of these systems, a long time macerated, varies equally; this undoubtedly would not happen, if, as Haller has advanced, the cellular texture was the only base, to which all the organs are brought by maceration. But let us return to the arteries.

Not only their fibres are not formed of cellular texture; but as I have said, they do not contain it in their interstices, a character in which it differs from all the other systems. The most careful dissection does not show it. When we separate the fibres from each other, we see, either that they are merely in apposition, or that they are held by little elongations of the same nature as themselves. I have said that this absence of the cellular texture is observable between the proper and common mem-

branes of the arteries, though Haller has pretended the contrary.

I believe that this absence of cellular texture contributes much to the kind of brittleness that particularly distinguishes the arterial texture, and which, as I have observed, renders it the least fit of all the animal textures, to support ligatures without breaking. It is to this circumstance also that must be referred the difficulty, the impossibility even of arterial dilatations, of the formation of cysts by the parieties of arteries. There are never, we know, true aneurisms; when these tumours increase at all, the two membranes of the artery break and the cellular coat alone is dilated. Hence the necessity of the peculiar structure which distinguishes the cellular texture placed around the arteries, and gives it a resistance that it has not in most other parts. Authors are astonished at these ruptures which distinguish the dilatations of the arteries from those of all the other systems. If they had compared the texture of the arteries with that of the other systems they would have seen the reason of this difference.

We easily understand, after what has been said, why there is never fat in the arterial texture; why it is never infiltrated in dropsies; why it does not develop hydatids and cysts in its layers, why the different tumours, for which the cellular texture serves as a base, as we have seen, do not appear in the arteries, &c. When an artery has been wounded, either longitudinally or transversely, we do not see fleshy granulations arise from the edges of the wound; I do not know that surgeons have seen them in the operations for aneurisms. Never, in the numerous cases in which I have had occasion to cut the arteries, in animals, and then leave them free, after having interrupted the course of the blood, have I observed any thing like it. If an arterial trunk is laid bare, the cellular coat often furnishes these granulations; but we never see them, if this coat is removed.

Exhalants and Absorbents.

Are there exhalants in the arteries? Nutrition undoubtedly supposes them; but it is not probable, as I have said, that they open upon their internal surface.

As to the absorbents, I thought for some time, that the absence of blood in the arteries, after death, arises from this, that their lymphatics preserving still the absorbent faculty for some time, take up the serum which is separated from the crassamentum. But lately experiments have undeceived me. I have enclosed blood, water, the fluid of dropsies, &c. between two ligatures made above and below on the common carotid, the body of which had been so managed on the exterior as not to break the vessels that come to it. At the expiration of a considerable time I have not discovered any diminution in the fluid. There had been then no absorption. I would observe that on account of the want of collateral branches, the carotid is alone proper for these experiments, and a variety of other analogous ones.

We know that the absorbents abound where there is cellular texture, and that they are wanting usually where there is none. It is probable then that the absence of this texture produces also the absence of these vessels.

Nerves.

1st. The first tree of the system with red blood, receives almost exclusively cerebral nerves. We know in fact, that the par vagum is spread upon all the pulmonary veins, as well as upon the neighbouring vessels of the lungs, which hardly receive any from the inferior cervical ganglion. 2d. The middle portion of this system, that in which the heart is found, derives its nerves almost as much and even more, from the ganglions, than from the brain. 3d. The great tree with red blood, or the arterial, is almost exclusively embraced by the first class of nerves.

We have said how these nerves go in this respect. The cerebral which accompany them, furnish hardly any filaments to the arteries. There is merely juxta position as we see it in the extremities, in the intercostal spaces, &c.

I cannot repeat it too much, that the constant relation of the arteries with the nervous system of the ganglions, deserves the attention of physiologists, because it is too general not to belong to some great object of the functions of the economy, though the object may be unknown.

ARTICLE FOURTH.

PROPERTIES OF THE VASCULAR SYSTEM WITH RED BLOOD.

WHAT we have to say of these properties, will refer particularly to the arteries, as well as what we have said of the organization. In fact the fleshy parietes of the heart and the membranous ones of the pulmonary veins, possess properties that will be examined hereafter, and which differ from those of the arteries, on account of the the difference of texture. As to those of the common membrane they are nearly the same in the whole course of the red blood, the organization differing but very little.

I shall consider the properties of the arteries only in the arterial texture and in the common membrane; for the cellular coat belonging to the system of that name, partakes of all its properties.

I. *Physical Properties.*

Elasticity, which is obscure in most of the other animal textures that are characterized by a great degree of softness is very remarkable in the arteries; it is this that particularly distinguishes them from the veins. This elasticity keeps their parietes apart, though they may be empty.

These tubes, with the cartilaginous, as the trachea, the meatus auditorius of the fœtus, &c. which are equally endowed with elasticity, are the only ones that keep thus open of themselves. All the others have their parietes applied to each other, when the fluid that runs through them does not distend these parietes.

It is to the elasticity of the arterial parietes that must be referred their recovering themselves when they have been flattened so as to obliterate their cavity, the sudden straightening of an arterial tube that has been bent, &c.

This property takes also an evident part in that kind of locomotion the arteries have upon the entrance of the blood. In fact, lay bare a tortuous arterial trunk in a living animal, you see the whole of it rise at each pulsation, leave the place it occupied, and straighten itself, particularly at its curves. At the moment the injection penetrates a very thin small subject, we perceive also through the integuments, a locomotion of all the tortuous branches of the face. Now it is evident that if the arteries were not of a firm and elastic texture, they would not thus obey the motion that is impressed upon them; besides, observe what takes place in the injection of the abdominal branches of the vena porta, which having no valves can be injected like arteries. Nothing similar to the locomotion of which I spoke is observed in driving the fluid into them. I have often made arterial blood circulate in the veins by the means of curved tubes, fitted to the vessels of a living animal, for example, by making the carotid and external jugular communicate; now, we observe clearly in the veins carrying the red blood, a kind of pulsation synchronous with the beating of the heart, and a distinct rustling noise, but not a real locomotion.

The locomotion of the arteries supposes three things, 1st, an agent of impulse, that communicates a motion more or less strong, to the blood contained in their interior; 2d, a tortuous arrangement which allows the blood

in striking their parietes to straighten them; 3d, the firmness and elasticity of these parietes which facilitate this straightening. On the other hand, the parietes must not be too firm; thus the cartilaginous texture would be improper for this locomotion.

The elasticity of the arteries is as striking after death as during life; it is essential to distinguish it from contractility of texture. There are many distinctive characters, the following are the most striking; 1st. The contractility of texture takes place only when there is a want of extension of the arterial parietes, that is to say, when these vessels cease to contain the blood which resists their contraction, or when they are cut and afterwards left to themselves. On the contrary, elasticity requires for its exercise, a previous compression and is manifested by the sudden return of the parts to their natural state. 2d. Contractility of texture has a permanent tendency to contraction; we may say that all the parts that possess it are in a forced state; so that as soon as this state ceases, contraction takes place. On the contrary, elasticity has not this constant tendency to exercise. 3d. Every elastic motion is brisk, sudden, as quick to stop as to begin. On the contrary, every motion of contractility of texture is insensible, slow, continues often many hours and even days, as we see it in the retraction of amputated muscles, &c. 4th. Every organ in which there is contractility of texture, enjoys necessarily extensibility. On the contrary, this last property is not necessarily connected with elasticity, as we observe it in the cartilages of animals, &c. 5th. Elasticity is purely a physical property. Contractility of texture, without being vital, is only inherent in the organs of animals.

II. *Properties of texture. Extensibility.*

The extensibility of the arteries may be considered, 1st, transversely; 2d, longitudinally.

The arteries have but little extensibility in the direction of their diameter. 1st. Whatever efforts are made to dilate them by injections of water, air, fat substances, &c. their caliber is rendered but little larger than natural. 2d. I have said that their texture is remarkable by a kind of brittleness, that when the blood distends them a little in aneurisms, this texture breaks instead of yielding, and that it is only the cellular coat, which, by the extensibility it has from the system from which it is derived, that is fitted to form the cyst that contains the blood. It is this that essentially distinguishes aneurismal from varicose tumours. 3d. If we tie superiorly the carotid artery of a dog, the blood pushed against the ligature that stops its course, reacts violently upon the parietes and yet the dilatation is hardly perceptible. We must not think however that the arteries do not yield at all. When the dilating cause acts slowly, it produces its effect to a certain determinate point, beyond which rupture takes place. The proof of this, is in the dilatation of the arch of the aorta, in that which true aneurisms present in their early stages, &c.

Longitudinally, the arteries are more capable of stretching, than they are transversely. We may be convinced of this, by drawing out these vessels, to place a ligature upon them in an amputated stump. By cutting upon a dead body a portion of artery, and drawing it in a contrary direction, it is evidently elongated. It is necessary in these experiments, to pay attention to the development of the folds. In fact, I have said, that this development of the folds performs a principal part in the elongation of the arteries situated in the parts that are dilated.

It is evident that in the extensibility in a transverse direction, it is the circular fibres of the peculiar membrane that especially resist; that on the contrary, in the extensibility in a longitudinal direction, it is the common mem-

brane that opposes the resistance, since there are no longitudinal fibres. It is not astonishing then that the first kind of extensibility should be less evident than the second.

Contractility.

It is necessary to consider it in a transverse and in a longitudinal direction.

Considered in the first point of view, contractility is much more evident than extensibility. When the artery is no longer distended with blood, it contracts in a sensible manner. It is to this contraction, that the following phenomena must be referred; 1st. the umbilical artery and the ductus arteriosus, become like ligaments after birth, by the adhesion of their parietes which are contracted. 2d. If we make a ligature upon an artery, the whole portion comprised between this ligature and the first collateral branch, soon exhibits the same phenomenon, as is proved by the operation for aneurism. 3d. If we include a portion of the carotid between two ligatures, and afterwards empty it by a puncture, it suddenly loses half its caliber. 4th. In dogs in whom I have transfused blood in order to produce artificial plethora, I have observed the arteries to be almost double in diameter, to what they are in those of the same size, who had suffered great hemorrhage. Two animals of the same size, one killed by hemorrhage the other by asphyxia, exhibit the same difference. 5th. These experiments shew me satisfactorily the cause of a large and small pulse, a cause admitted moreover by most physiologists. The artery is certainly more or less large, according to the quantity of blood that fills it. There is a point of extension that it cannot pass; but it contracts often for the want of blood, so as to be as it were, but a mere thread. 6th. Though you may have opened but few bodies, you have no doubt been astonished, that in those of the same size, the arte-

ries have often very different diameters. This arises wholly from what takes place at the moment of death. If, from the want of blood, the arteries are for a long time contracted, they remain in this state, as happens to the heart in death by hemorrhage, &c. This is so true, that arteries of different diameters commonly become equal by injection, which brings them to an uniform degree of extension that they cannot pass. 7th. In a longitudinal wound of arteries the ends of their cut fibrous circles separating from each other, a space, which does not close, is left between them.

Most authors have confounded contractility of texture of the arteries with irritability. I have no occasion here to show how much they are deceived. In none of the preceding cases, is it necessary that a stimulant should be applied upon the arterial texture; the only thing necessary is the absence of extension, a distinctive character of the contractility of texture. Moreover it is evident, that this property continues after death, though in a less degree than during life; whereas some hours after death, every kind of irritability disappears. I think that it is especially in the arterial system, that may be seen the advantage of my division of the properties of our organs. Read all the authors upon this system, and you will see that no one is intelligible, because they have not assigned the limits of the vital properties and those of texture.

Contractility of texture in the longitudinal direction, is in proportion less evident than in the transverse; it is however real. 1st. Thus when we cut an artery between two ligatures, the two ends retract immediately in an opposite direction. 2d. This retraction is evident in amputation; that of the muscles and the skin however is greater, the artery often projects a little. 3d. An artery, cut transversely in a portion of its parietes, often presents at this place a broad opening, arising from the retraction of the eut parts, as happens in a longitudinal wound of

which I spoke just now. 4th. When we draw an artery forcibly and suddenly let it go, its retraction is very evident. In making this experiment upon an animal, the vessel buries itself in the flesh. Hence why, the spermatic artery and cord, drawn down by the weight of the testicle, often ascend into the abdomen after it is removed, if care is not taken to prevent them.

It is this circumstance that has induced me to propose for the operation of sarcocele, a modification which consists, after having dissected around the cord after the first incision, 1st, in searching immediately for the vas deferens, which is easily found by its extreme hardness; 2d, in giving it to an assistant to hold; 3d, in passing a bistoury between it and the blood vessels; 4th, in cutting the blood vessels first and leaving the vas deferens untouched; 5th, in afterwards tying the artery, which is easily discovered by the jet of blood; 6th, and then, when this is done in cutting also the vas deferens. It is evident, that by this section at two different times, we have the advantage of applying the ligature without fear of the retraction of the artery, since the vas deferens to which it adheres, and which is not cut, until it is tied, is sufficient to retain it. I have not performed the operation; but it is evident that there is nothing to prevent the execution of this plan, since the parts are sound where we cut. I have moreover always taught the student to manage in this way with ease. It is especially when it is necessary to cut the cord very near the ring, because it is diseased in its course, that this method of operating appears to me to have great advantages.

I think that the retraction of arteries that have been drawn, and their contraction afterwards, perform an important part, in producing the absence of hemorrhage in most wounds by laceration, a singular phenomenon, that particularly distinguishes these wounds from those by cutting, even when a considerable vessel happens to be

in their course. Many authors have given examples of this; we find some particularly in the works of Sabatier.

III. *Vital Properties.*

Properties of Animal Life. Sensibility.

Have the arteries animal sensibility? Upon this point, facts teach us what follows; 1st. The ligature of an artery sometimes produces a painful sensation, more frequently it does not. It is especially in the spermatic that the pain is frequently felt, but this can be referred to the nerves. 2d. I can without exaggeration say, that I have made experiments upon more than a hundred dogs, in whom I have forced various substances through the carotid to the brain, and have irritated this artery with the scalpel, acids, alkalies, &c. but that the animals have never given any marks of pain. Many authors have obtained similar results. 3d. I would observe also, that it is an additional proof of the kind of insensibility of the nerves of organic life, which as we have seen are distributed to the arteries. 4th. This is what I have observed concerning the irritation of the common membrane of the red blood; the injection of a mild fluid at the temperature of the animal produces no effect; but an irritating fluid, as ink, a solution of acid, wine, &c. creates severe pain equal to that arising from the irritation of the most sensible parts, if we may judge by the cries and agitation of the animal, the moment the fluid enters the carotid.

Contractility.

Animal contractility does not exist in the arteries. In fact this contractility could only depend upon a relation between these vessels and the brain, by the means of the nerves; now, 1st, any irritation produced upon this last viscus, occasioning convulsions in the organs under the influence of the will, has no effect upon the arteries. 2d.

Opium, which in a certain dose, paralyzes, if we may so say, the same organs, leaves the arterial motion wholly unaffected. 3d. If we lay the spinal marrow bare, and irritate or compress it, the action of the arteries is neither increased or diminished, whilst the voluntary muscles become the seat of convulsions or paralysis. 4th. No effect is produced upon the arteries by different irritations, whether of the nerves of the cerebral system, which accompany the vessels without giving them any apparent filaments, or of the nerves of the system of ganglions, which are distributed irregularly and in very great number upon their external surface. 5th. To remove all doubt upon this subject, I selected galvanism, the most powerful kind of excitement. Without effect did I arm on the one hand the cerebral nerves, on the other, the arteries that are joined to them; the contact of the two armed points does not produce in the arteries the motion it excites in the muscles in which the nerves are spread. The effect is the same in experiments upon the nerves of the ganglions. I armed on one hand the upper part of the mesenteric plexus, on the other, the arteries of the same name, first stripped of their serous and cellular coat; the contact was entirely without effect. The arterial system does not possess that faculty of motion which the action of the brain is capable of producing. All that has been written by different authors, by Cullen in particular, upon the nervous power, upon the action of the brain on the arterial system, is vague, illusory and contradicted by experiment.

Properties of Organic Life. Sensible Organic Contractility.

The sensible organic contractility is evidently wanting in the system of which we are treating. In whatever way we irritate an artery in a living animal, it remains uniformly immoveable. 1st. If we stimulate the external surface with a scalpel or any other instrument, it is easy

to make this remark. 2d. The same observation is made when we excite the internal surface, an experiment that I have often made, because we know that the heart is more irritable internally than externally. 3d. An artery cut longitudinally in a living animal does not turn over at its edges like the intestines in similar circumstances. 4th. An arterial tube, drawn out of the body, never gives like the intestines, the heart, &c. any mark of contractility. 5th. If we raise the arterial plates, layer by layer, in a living animal or one recently killed, we see nothing of that trembling, that palpitation that the fibres of the organic muscles exhibit under like circumstances; on the contrary, we observe in them a kind of inertia very analogous to that of tendinous, aponeurotic fibres, &c. 6th. It is said, that by placing the finger in an artery, a contraction is felt. I have often made this experiment; the contraction is infinitely less sensible than has been said; besides it is produced evidently by the contractility of texture. 7th. Lamure says, that a portion of blood being intercepted between two ligatures in an artery, the parietes of it continue to contract, though deprived of the influence of the heart; this is not correct. It is so important that I have examined it myself; I have repeated this experiment at least ten times upon the carotid; the following has always been the result; the tube comprised between the two ligatures and filled with blood, is agitated by a real motion, but it is only that of the common locomotion that it partakes with the whole artery, and which arises from the impetus of the blood against the ligature nearest the heart. To be convinced of this, it is only necessary to lay bare a considerable portion of this artery; we see evidently that the whole tube, whether the portion nearest the heart, or that comprised between the ligatures, or that which is beyond, is agitated by a common motion. 8th. Instead of the blood I have intercepted different irritating fluids in a portion of an artery; there is

the same inertia, the same want of contraction in the parietes; but the same motion derived from the general locomotion. 9th. Many authors have produced a contraction on the part of the arteries by stimulating them with concentrated acids. This is true, and I have also produced this effect; but it is not the result of contractility, but it is the horny hardening. Observe also that the arterial texture never returns to its primitive state after a contraction like this; that the alkalies, that are as irritating as the acids when the vital forces are excited, have no effect here; it is the same phenomenon during life, as that which we have spoken of as taking place after death.

There can be no doubt, I think, after this, that the arteries do not exercise during life any kind of contraction by themselves and under the vital influence. All that has been said upon this point, is the evident effect of the contractility of texture. Thus when we open an artery between two ligatures, it empties itself of the blood it contains, or of the fluid that is accidentally pushed there; the same phenomenon takes place when we place only one ligature that intercepts the influence of the heart, &c. It is so true, that all these phenomena and other similar ones depend upon the properties of texture, that they take place in the dead body as long as an artery is not putrid. Fill any portion of the arterial system, afterwards open one of its tubes, it empties itself immediately by contracting. The contraction produced by the defect of extension, is that which characterizes the contractility of texture. Irritability or sensible organic contractility, supposes on the contrary uniformly the application of a stimulus.

Insensible Organic Contractility.

Insensible organic contractility or tone very evidently exists in the arteries. In the great trunks and wherever

the pulsation is sensible, its functions are limited exclusively to nutrition and exhalation, if this last takes place in the interior of arteries, which I do not believe. But when the influence of the heart upon the blood contained in these vessels ceases, which happens at the commencement of the capillary system, then the tone begins to have an influence not only upon the nutrition of the vascular parieties, but also upon the circulation that is going on there; it is even wholly by the tonic powers, as we shall see, that the circulation of the small vessels is carried on; the heart has no influence there. I shall treat of this property under the general capillary system; here it performs but a very weak part.

As to organic sensibility, it evidently exists in the arteries, since it cannot be separated from the preceding contractility; like it, it is obscure in the great trunks, which have only what is necessary for their nutrition.

From the small development of the organic forces of the arterial texture, it is evident that this texture would rarely be the seat of affections, over which these properties particularly preside. This also is proved by observation.

1st. Acute diseases are rarely observed in the arteries. Among all the bodies that I have examined, I have found but very few in which there were traces of inflammation in the arterial texture. I would observe upon this subject, that it is necessary to distinguish accurately the redness which is, as we have said, the effect of maceration, and which even appears spontaneously in the dead body some time after death, especially in the cerebral arteries; it is necessary, I say, to distinguish it from that which arises from inflammation. In one the arterial fibres are really red, in the other they appear so only by the injection of their vessels. Is the common membrane inflamed in inflammatory fever? I am entirely ignorant. These simple fevers are so rare, especially in hospitals

that we have hardly an opportunity of examining patients that have died of them. But by supposing that this inflammation existed, the infrequency of these fevers considered in their simple state, would prove even how little the arteries are disposed to inflame. 2d. The arteries are not often the seat of chronic affections. Except on the one hand aneurism, in which the arterial texture is hardly altered, but merely broken, and in which consequently its organic sensibility performs but a very small part; on the other, the osseous incrustations, most of the alterations that are so frequent in the other textures, are not observed in this.

This texture must be ranked with the cartilaginous, the fibro-cartilaginous, the fibrous, the muscular even, &c. as it respects the infrequency of organic alterations. These textures exhibit a phenomenon opposed to that of the serous, mucous, glandular, dermoid systems, &c. which are especially characterized by the frequency of these alterations. Compare the organic properties, the sensibility and insensible contractility in the two classes of textures; you will see them very feeble in the first, in which in a natural state, they preside only over nutrition; you will observe, on the contrary, that they are very evident in the second, because there they preside over nutrition, exhalation, absorption, secretion, &c.

The difficulty with which the arterial texture inflames and participates in the different alterations of the neighbouring organs, preserves the integrity of the circulation in many cases. What would become of this function, if the arteries received as easily as the other textures, the influence of surrounding diseases? Placed at every moment by the side of inflamed, suppurating, swelled parts, &c. if they become changed by their neighbourhood, especially in the great trunks, a general derangement would soon be felt in the motion of the blood. Dissect the arteries in the organic affections of the stomach, the

liver, the spleen, &c.; they are untouched, and only a little increased in size; whilst a general swelling seems to confound in a new mass all the neighbouring textures.

The clots in aneurism adhere sometimes so intimately to the common membrane, that we are obliged to remove them with an instrument. But this adhesion is entirely inorganic; it is a kind of agglutination, that would imply the small degree of life of this common membrane, as the facility with which colours are fixed in the epidermis implies it in this last organ.

Remarks upon the causes of the motion of the red blood.

The red blood is moved in the heart by a mechanism which there is no difficulty in understanding. But an important question remains to be decided concerning its motion in the arteries; are these vessels active or passive in this motion? When the physician examines the different states of the pulse, is it the state of the heart or that of the arterial system that he ascertains? From the absence of sensible organic contractility, as we have observed in this texture, it is evident that its part would be especially passive; that the motion of which it is the seat is communicated to it; that the heart is the great agent of the pulsation of the arteries; that it is that which gives the impulse, which these vessels only obey, and that consequently in almost all cases the state of the pulse is the index of the state in which the vital forces of the heart are found, and not of the state of the arterial system, whose life is not more raised in the greatest and most frequent pulsatory motions, than in the feeblest and most infrequent. Thus in convulsions, the principle of which is a wound, an irritation of the brain, &c. the nerves, though conductors, are, if we may so say, passive.

I will now examine in detail this important question, that so many physicians have considered differently.

Influence of the heart in the motion of red blood.

1st. The first reason that induces me to believe that the heart is almost every thing, and that the arteries are particularly passive on the score of vitality in the motion of the red blood, is the comparison of the vital forces of these two organs, the astonishing activity of the organic contractility of the heart, and the absence of this property in the arteries. In fact, to move of itself, it is necessary that an organ should have the principle of motion, that is to say, one of the two kinds of vital contractility in a sensible degree, the organic or the animal; for we do not know of other vital forces in the animal organs, and we cannot say that nature has created one especially destined for the arteries. Grimaud admitted that there was an active dilatation of the vessels, which opened of themselves, according to him, to receive the blood, and were not opened by its impulse. We shall see that this kind of motion is real, to a certain extent, both in the heart and in the organic muscles. But here it is wholly different; the heart dilates of itself when it is empty, as we see by drawing it out of a living animal, and by emptying it afterwards of the fluid it contains, because it has in itself the cause of its dilatation. But in no case have I seen the arteries thus undergo an alternate motion when they are empty. They are uniformly found contracted upon themselves.

2d. If the arteries produce the pulse by their vital contraction, there ought to be an irregularity in the pulsations below an aneurismal tumour, since the arterial texture being altered, it loses in part its contractility, or at least this property is changed. Now we observe precisely the contrary. On the other hand, every organic disease of the heart inevitably affects the pulse. Is there an increase of the fleshy fibres, as in the aneurisms in which the left ventricle is so thick? it becomes strong:

it is irregular, if obstructions exist at the mitral or aortic valves. If in old age, ossification exists only in the arteries, the circulation is unaffected; if at the origin of the aorta or in the heart, it is irregular. An artery might become a bony canal, and the blood would circulate there as usual, with the difference only of pulsation. What I have said of the chronic affections of the heart may be said of the acute ones. Syncope arrests its motion, it arrests also the pulse. Certain passions, as anger, fear, &c. seem to be a stimulant to it; they hasten also the arterial motion. All kinds of inflammation of the pericardium affect the pulse. This membrane often adheres to the heart in consequence of inflammation, and at the same time the pleura of both sides adheres to it also; so that we might say then that the lungs and the heart made but one. I have seen four examples of this morbid state, in which the motions of the heart were much contracted; in all the pulse was small, irregular, and intermittent. The more I open bodies, the more I am convinced that when the irregularity of the pulse is uniform for a considerable time, there are almost always organic affections of the heart; from which there is reason to believe that the irregularities of the pulse that are acute, if I may use the term, arise from an alteration, not in the texture, but in the vital forces of this organ, and that the arteries are almost entirely disconnected with it. We know how frequent these irregularities are in acute diseases. Since then every alteration of the heart essentially affects the pulse, and those of the arteries on the contrary, leave it unaffected, we should certainly conclude from this, that the one is essentially active in this great phenomenon, and that the others, on the contrary, are almost passive.

3d. There is no doubt that at the instant a ligature prevents an artery from receiving the influence of the heart, it ceases to beat. All the phenomena of aneu-

risms, treated by compression or by ligature, establish this fact. If the contrary has sometimes been observed, it arises only from anastomoses, and then it is equally the heart that makes the artery beat above and below the ligature. It is absolutely false, as I have said, that an artery never beats between two ligatures. Often in aneurism the artery being compressed below the tumour, this beats much stronger than before.

4th. Cut off the arm of a dead body, and make it pliable by leaving it for some time in a tepid bath. Fix afterwards to the brachial artery a small tube; place the other extremity of this tube in the open carotid of a large living dog; immediately the heart of the animal will drive blood into the arm. The artery will have a kind of pulsation, less, without doubt, than in a natural state, but sufficient to be perceived even through the integuments. I have often repeated this singular and curious experiment, of which I shall have occasion to speak again. It was suggested to me by another, of which I have given an account in my Treatise on the Membranes, and which consists in making the red blood circulate in the veins, without the motion of locomotion, it is true, but with a rustling sensible to the finger, and with a velocity almost equal to that of the arteries. This last experiment alone would prove that the heart is almost the only agent of impulse of the blood circulating in the arteries; in fact, every throw of blood coming from the veins is uniform, because the capillary system pours without a jet this fluid into these vessels. On the other hand, every arterial throw is by jets, which are produced by the contraction of the heart. Now if you open a vein in which you have made red blood circulate by a curved tube, the throw of blood will be in jets, which will correspond to the contractions of the heart. With the difference merely of locomotion, a vein presents during the circulation of the red blood, the same phenomena as an

artery. Make, on the other hand, the reverse of this experiment, that is to say, fit a curved tube to a vein and an artery, so that the blood of the first may flow into the other; the artery will lose immediately its pulsatory motion, unless it be kept up in the collateral branches; this does not happen if we select great trunks, for example, the crural and corresponding vein. It is evident, that all these experiments, which I have frequently repeated, would give a result entirely opposite, if the arteries took an active part in the circulation by their vital properties.

5th. The force of the heart makes the blood circulate through inert tubes, fixed to the arteries, to a considerable extent. If we cut an inch of the carotid artery, and substitute a tube fixed to the two open ends of this artery, the blood will go through this tube and the artery pulsate as usual above. I cannot imagine in what way those have been deceived who have obtained different results.

6th. Take two dogs; fix the end of a tube to the carotid of one, on the side of the heart, and the other end of the same tube to the crural or carotid of the other, on the side opposite to this organ; the heart of the first will uniformly make the arteries of the second pulsate, by sending blood to them. All my experiments upon death, experiments already published, have shown me this phenomenon. Besides, in aneurism the pulsation takes place below the tumour; yet at that part, the two ends of the broken artery are separated; the cellular membrane alone serves to unite them, by forming the cyst. The blood passes then through an intermediate body that is not arterial.

7th. Fix to an artery one end of a tube, which has at the other a sac made of skin, or gummed taffety, the blood will fill it immediately; then at each contraction of the heart, it will have a sort of pulsation. It is thus that the aneurismal tumour pulsates, which is cellular.

Whatever may be the organ that contributes to form the cyst, it would pulsate, provided it received, with the blood, the impulse of the heart.

8th. I would ask, if the active dilatation of the arteries could be sufficient to raise the brain, impart a motion to the leg that is crossed upon that of the opposite side, to overcome the weight of the tumours that are situated in their course, and raise them at each pulsation. It evidently requires a more powerful organ to produce these phenomena, and this organ is the heart.

9th. How is it, that the pulsation of all the arteries is simultaneous, if a single centre does not preside over this pulsation? The whole arterial system, struck suddenly with the same blow, is raised and pulsates at the same time. Is it not evident, that if the arteries contracted by themselves, the least derangement in one part, the least pressure, &c. would produce a discordance in the motions?

10th. No animal has arterial pulsations, if it has not a heart, or a fleshy vessel, knotty, and divided by contractions, as in many insects; have the pulsations of this vessel, which is a substitute for the heart, been well observed? It is thus that the system of the vena porta never has pulsations, though its hepatic part is arranged like the arteries.

11th. The two ends of a cut artery pour out blood, but this is the effect of the anastomoses, and not of the re-action of the end opposite to the heart, as I thought myself for some time. It is for the same reason that an artery can pulsate sometimes below a ligature.

12th. I have no doubt but that without the heart, the red blood would have in its great canal, a kind of motion, a motion that would resemble that of the vena porta; it would be entirely without pulsation.

13th. Cases have been quoted, in which the motion of the arteries was said to take place as usual, though they

contained no blood. I confess that I dó not know how we can be assured of this fact. But if it was real, it must be placed at the side of that of the soldier, who could stop the motion of his heart at will. What can we conclude from an insulated phenomenon, which is in contradiction to all those that nature daily presents? It may not be useless, I think, to remark, that since healthy physiology has advanced, has been studied with method, a love of truth, and a desire only to collect facts, we have no longer been presented with those extraordinary cases in which nature seems to depart from the laws she has imposed upon herself.

From all that has been said, it follows, I think, very evidently, that in the pulsation of the arteries, the heart is almost the only power that puts the fluid in motion; that the vessels are then passive; that they obey the motion that is communicated to them, but that they have none of themselves dependant at least on their vitality. Thus nature has chosen for the arterial texture one of those of the economy, in which life is the least evident; as the heart is remarkable for its vital properties, the arteries are remarkable for the absence of them. They must be ranked with the cartilaginous, fibrous, fibro-cartilaginous textures, &c. It is that they may not disturb the unity of impulse by their motions, that nature has thus formed the arteries. Suppose that they had the same vital forces as the intestines; what would become of life? Any convulsive contraction a little too strong in the aorta or in the great trunks, by contracting their caliber too much, would arrest the circulation, and produce the most serious effects by agitating it in an opposite direction to the heart. In the intestinal canal, this phenomenon only produces vomiting. It would produce death suddenly in the arterial system. The more attentively we examine, the more we shall be convinced of the necessity of having but one agent of impulse for

the arterial system, and of having this system inert, so that it cannot be able to arrest the course of the blood.

I do not say that the arteries can never contract from the vital influence; the skin which is not irritable, wrinkles by cold. But the cases are very rare, in which the arteries contract. When they exist they cause an inequality of the pulse on the two sides; an inequality rarely noticed in diseases.

Of the limits of the action of the Heart.

The heart is then the essential cause of the pulse; it is this which puts every thing in action in the arterial motion. Many authors have overrated its influence; they have thought that its impulse was sufficient to produce, not only the arterial motion, but also that of the general capillary system, and even that of the veins; so that the contraction of the left ventricle alone is the cause, according to them, of the long course the blood runs from it to the right ventricle. But it is incontestably proved, as we shall see, that when this fluid has arrived in the general capillary system, it is absolutely beyond the influence of the heart, and that it moves only by that of the tonic forces of the small vessels, and therefore for a stronger reason, the left ventricle has no influence in the venous system. It is in this respect that the authors, of whom I have spoken, have erred, and not under that of the impulse that they have admitted in the arterial system on the part of the heart.

We can, I think, establish nearly the limits of the influence of the heart upon the blood, by fixing them where this fluid is transformed from red to black in the general capillary system. As it advances in the small vessels, the impulse received is undoubtedly weakened, and the small vessels supply it by their insensible organic contractility; but I believe that the motion received from the heart, is not entirely lost until at the place of the change into black

blood; so that we can establish for a general principle, 1st, that in the great trunks, in the branches and even in the smaller branches, the heart is almost every thing for the motion of the blood; 2d, that in the ramifications, it is in part this organ and in part the vital action of the arteries, which contributes to this motion; 3d, that finally it is this vascular vital action alone in the general capillary system.

The pulse exists in its fulness, only in the trunks, the branches, and the smaller branches. It is evidently weakened in the ramifications; it becomes nothing in the capillary system. The arterial texture of the great trunks is provided, as we have seen, with insensible contractility. But the impulse received by the heart is on the one part so strong, and the column of blood so great, that the influence of this kind of contractility is really nothing. Irritability alone could have influence; but this does not exist in the arteries. On the contrary, in the small vessels, the shock on the one hand impressed by the heart is insensibly weakened; on the other, the streams of blood being so fine, they have no occasion for any thing to produce their motion, except a kind of oscillation, an insensible vibration of the vascular parietes. It is this that essentially distinguishes the two kinds of organic contractility. The one is exerted only upon the fluids in mass, as upon the blood, the aliments, the urine, &c. The other causes the motion of the fluids when divided into small streams; it presides over the capillary circulation, exhalation and secretion. The influence of the first is very considerable wherever there is a great cavity, as the stomach, the bladder, the intestines; that of the other takes place only in the small vessels. As long as the blood is in a considerable mass, the heart must inevitably be the agent of impulse, the arteries cannot be, from their want of irritability. When it is in very small streams, then it moves by the insensible contractility of the vessels. This

then is the part which this property performs in the system with red blood; 1st, it exists in the trunks, the branches and the smaller branches; but its effect is nothing where that of the heart is evident. 2d. That of the heart being weakened in the ramifications, its own contractility begins to have an influence. 3d. Finally, the heart ceasing to agitate the blood in the general capillary system, the insensible organic contractility or tone, is the sole cause of motion.

Phenomena of the impulse of the Heart.

What part then have the arteries in the pulse? The following is what takes place in this great phenomenon; the arteries are always full of blood, the impulse that the blood in them receives from the left ventricle, is felt at the instant in the whole system, and even to its extremities. Imagine to yourself a syringe, the tube of which gives rise to an infinity of branches, which afterwards give origin successively to a number of smaller ones; if, when you push the piston of the syringe, its body and all the branches and smaller branches arising from it, are already full of fluid, it is evident that at the very instant in which the piston shall push the fluid in the body, it will go out on all sides through the open branches. Now suppose, that instead of a piston, you could make the parietes of the body of the syringe suddenly contract, the fluid at the instant of the contraction would spout out on all sides from these open branches. Another comparison will render this more evident; strike at one end of a long timber, the motion will be suddenly felt at the opposite one.

We can from this form an idea of what takes place at the instant of the contraction of the left ventricle. Authors have spoken of a wave or undulation of blood, being propagated through the whole arterial system, and formed by the two ounces of blood that are poured into the

arteries at each contraction. The arterial motion should be thus considered, if the arteries were empty at the instant of contraction; but in their state of fulness, the impulse is generally and suddenly felt, and with almost as much force at the extremities as at the origin of the arteries; it is only in the ramifications that the motion becomes a little weakened. Fill with water the arteries of a dead body, and fix a syringe full at the aorta; at the instant you push the piston, the water will spout out of the tibial or any other artery, if you loosen an opening that had been previously made in them.

The idea that is commonly entertained of the progressive motion of the blood, is wholly incorrect. This fluid has been considered as flowing in the arteries almost like water in brooks. It is not so. At each contraction of the ventricle, it experiences suddenly a general motion that is felt at its extremities. Do you wish for another comparison? Suppose a syringe, to the tube of which is fitted a series of elastic pipes arising from each other; push the piston, you will see all these pipes swell simultaneously, become straight, and the fluid flow at the same time to the extremities, if they are open.

It is not the contraction of the arteries that drives the blood to their extremities. This is so true, that if you open one of these vessels at a distance from the heart, each jet that the blood will make in going out, will correspond to each contraction of the ventricle. Now if the arteries drove the blood to all the extremities, by contracting, their contraction and relaxation would alternate with those of the heart; but if it was so, each jet of the arterial throw should correspond to each relaxation of the ventricle; the contrary of this is the case as I have just said.

From this we see how very inaccurate is the common opinion, which I believed myself for many years, viz. that the auricles contract at the same time with the arteries,

and the veins at the same time with the ventricles. The circulation of red blood is thus explained; 1st, the pulmonary veins drive the blood into the left auricle. 2d. This by contracting forces it into the ventricle, which dilates to receive it. 3d. This last contracts afterwards, sends it to the aorta which dilates at the instant of contraction; 4th, then this contracts to drive it to all the parts. This last does not take place; you can never observe it like the others, in a living animal. Examine as closely as possible, a great artery laid bare; it rises, but it does not dilate hardly at all in an ordinary state, nor does it contract. Contraction of the left ventricle; general motion of all the arterial blood; the entrance of this blood into the capillary system, are three things that take place at the same instant. It is like the blow on the timber, that is felt at one end, at the same time that it is received at the opposite.

We can form a very accurate idea of the circulation by examining the mesenteric arteries through the peritoneum, after having opened the abdomen of an animal; at each pulsation you see them all simultaneously rise and pulsate at their extremity as well as at their origin.

It is impossible to form an idea of the arterial motion, by considering the wave or undulation of blood as extending itself at each contraction in the arteries, and arriving afterwards successively at the extremities. Read all the authors upon the circulation; you will see that there is no subject that is treated oftener or more at length, than that of the course of the arterial blood, and yet there is no one in which you are left in more doubt and obscurity. Why? because all go upon a false principle, and all the consequences are inaccurate, where the principle itself is not correct.

It is not the wave of blood going from the ventricle, that is driven at each contraction into the capillary system; it is the portion of this fluid which is found nearest

this system, as in the syringe, it is the portion that is in the tube that the piston forces out and not that with which it is in contact; whence it follows, that it is only at the end of some time that the blood arrives from the heart, at the general capillary system, that it remains during a number of contractions in the arteries, and that it is only successively expelled; which favours the mixture of the different principles that compose it.

From this manner of considering the arterial motion, which is the only real and admissible one, it is evidently impossible that the curves can injure this motion, besides this is proved by many facts.

I consider also as destitute of every kind of foundation all that has been said in the books of physiology, upon the causes of the delay occasioned in the course of the blood, 1st, by its passage from a narrower to a broader place, and by the conical form of the general arterial system; 2d, by friction; 3d, by the angles; 4th, by the anastomoses which give an opposite shock, &c. &c. All this would be true if the arteries were empty at the time of contraction, because the blood would then have in them, truly a progressive motion. But in the general and instantaneous impulse that the whole mass spread in the arterial system experiences, all these causes are evidently nothing. I return now to the trifling but very accurate comparison of the syringe. Suppose that a tube twisted in a thousand ways, with numerous angles, inequalities, internal projections, &c. was fixed to it; if the tube and the body of the syringe are full at the instant we push the piston, the water will escape suddenly from the extremity of this tube with as much force as if it was straight and short. It is so true that all the causes of delay, which would have some effect, if the arteries were empty at the instant the blood is driven into them, have none in their ordinary state, that many judicious observers, who even admitted the delay, have seen in their experiments that

the motion was every where the same, in the smaller branches as in the trunks. Why did not this undeceive them? We know that the pulse is the same in all parts of the arterial system; how could it be if there was this delay? What has greatly retarded the progress of the physiology of the circulation, is the idea that is attached to the velocity of the course of the red blood. This velocity cannot be rightly estimated, because the motion is not successive, because, to speak correctly, the blood does not flow; it is suddenly driven by a general impulse, in which we cannot calculate any thing.

Philosophers have calculated the motion of fluids, where their particles are successively displaced, as in the course of a river; but they have paid less attention to that brisk motion of the whole or of the mass, if I may so say, that takes place in canals in which they are enclosed on all sides, and are acted upon at one extremity.

Remarks upon the Pulse.

Two things are already evidently proved, viz. 1st, that the heart is the peculiar agent of the arterial motion, and that the arteries are almost passive in this motion; 2d, that it consists in a general impulse suddenly experienced by the whole mass of red blood, felt at the same time at the extremities and in the trunks, and not in a successive progression of a wave or undulation that goes from the left ventricle. It remains for me to examine how the heart produces the pulse by this brisk and instantaneous motion. There is still much to be elucidated upon this point; but we cannot deny that the locomotion of the arterial system does much in this phenomenon. At the instant the mass of blood is driven thus from the heart towards the extremities, by a motion of the whole, if we may so say, it tends inevitably to straighten the arteries, especially when they are tortuous. This straightening necessarily produces a locomotion, which causes the pulsation of the artery.

As to the dilatation, it is hardly any thing in an ordinary state; however if you press a little upon an artery, the blood makes an effort to dilate it and this effort increases the sensation of the pulse; Jadelot thought that it alone constituted it. On the other hand, if much blood enters the arterial system at the instant of the contraction of the heart; if a resistance exists in the general capillary system, the arteries can be also dilated, but it is not their return upon themselves or contraction that drives the blood into the capillaries; this return is subsequent. In fact, at the instant of contraction, the blood enters on the one part into the arteries in going from the ventricle, and goes on the other to enter the capillary system; these two phenomena take place at the same time, since they arise from the same impulse. Then when there is a contraction in the artery, a motion which is only the contractility of texture put into action, this contraction does not drive the blood; but it takes place, because the blood has been driven into the capillary system at the instant of the contraction; it is because the artery ceases to be distended, that it returns upon itself or contracts, and not because it is actually distended. Hence how the arterial contraction can alternate with that of the left ventricle; but it is not in the sense that authors have understood it. There are then two periods in the motion of the red blood; 1st, contraction of the ventricle; slight dilatation of the arterial system by the blood that enters it; general locomotion; passage into the capillary system of a portion of this red blood; all these phenomena happen at the same time; it is the period when the pulse is felt; it is that of the diastole. 2d. In the next period, the ventricle is relaxed to fill itself anew; less full of blood, the arteries contract a little upon themselves; all take the place they had lost during the locomotion; this is the period of the systole, a period purely passive, while some have thought it a very active one for the arteries.

As but little blood is driven at each pulsation out of the ventricle, which does not wholly empty itself; and as, on the other hand, at the same time it enters the arteries it goes out from the side opposite to the heart, the arterial dilatation and, consequently, contraction, are almost nothing; thus, they cannot be perceived. Besides, if the contraction really took place, it would hardly be apparent; for when it is the contractility of texture that is in action, it produces a slow insensible motion, a real tightening; whereas contraction, the effect of irritability is abrupt, instantaneous, and produces a motion that the eye always distinguishes.

I cannot insist too much upon this fact, which is certain, viz. that if there is a slight contraction in the arteries at the instant the pulse ceases to beat, it is not that they have contracted to drive the blood, but merely that they contract upon themselves, because the blood that has gone into the capillaries prevents their being sufficiently dilated; it is contractility for the want of extension. Hence why the throws of arterial blood going from an open artery, correspond with the dilatation of these vessels, and the weakening of the throw with their contraction, which would be entirely the reverse, according to the common opinion.

The dilatation and contraction of the arteries being almost nothing in the ordinary state, it appears that the peculiar cause of the pulse is, as Weitbreck has observed, in the locomotion of the arteries, a locomotion that is general and instantaneous in the whole system, and not consecutive, as this author has understood it. I shall not relate here the proofs of this locomotion; they can be found every where. I would observe only, that it is so manifest in living animals, that when we have often examined the circulation by their means, it is impossible to doubt its reality.

Different causes can make the pulse vary; these causes are, 1st, relative to the heart, almost the only agent of impulse; thus its sensible organic contractility, increased, diminished, altered sympathetically or in any other way, can make it with the same stimulus contract quicker, slower, or more irregularly than common; thus the diseases of its organization inevitably alter its motion. 2d. The blood charged with different natural or morbific substances is a stimulant more or less capable of putting in play the motion of the heart. 3d. The general capillary system, according as it receives a greater or less quantity of blood, or refuses admission to that which the arteries send there, &c. produces necessarily numerous varieties in the pulse. There are but few causes relative to the arteries themselves.

If now we consider the great number of causes that can be referred to these three principal heads, we shall cease to wonder at the prodigious variety that the pulse exhibits in health, and especially in diseases. Besides, I shall not examine here in its whole extent the question concerning the pulse; it is sufficient to have announced the principles; I shall hereafter develop the consequences, which are, as we know, of the greatest importance to the physician. We see by the different views that I have presented, that almost all authors have described in an inaccurate manner the motion of the blood, and what loose ideas they have had of it. Experiments have only served to confuse them; it is a work that requires to be entirely done again, either with the materials that many respectable authors have already amassed, especially Haller, Spallanzani, Weitbreck, Lamure, Jadelot, &c. or with new facts. I have only presented the first bases of this work.

We have seen how favourable the firm and elastic structure of the arterial texture is to the locomotion of the arteries, and the influence the curves of these vessels

have upon it. I will add that the loose union that they form with the neighbouring parts, and their uniform position in the cellular texture, singularly favour this locomotion.

If the red blood flowed in the veins, we should feel under the finger a kind of rustling, instead of the motion of the pulse; this is what happens in varicose aneurism. There would be no locomotion if the arterial parietes were made of the dermoid, mucous, serous textures, &c. there would be different phenomena with the common impulse.

There are then two things in the pulse; 1st, impulse of the blood, sudden and general motion of its mass by the contraction of the heart; 2d, locomotion of the arteries, an effect produced by this fluid upon the arterial parietes which transmit it. The first is the most essential; as to the second, it would vary, if the arterial texture that produced it ceased to be the same; it depends upon this texture, and is not essential to the circulation.

When an artery is cut at the end of its trunk, the locomotion is much less sensible in this trunk, because less resistance is offered there to the course of the blood.

If an artery is opened laterally, it forms two currents of blood in an opposite direction, which are driven towards the opening, and which unite in one throw. One of these currents is direct, the other arises from anastomoses. It is the same as when an artery is cut, and the blood flows at both ends.

If an artery is wholly divided, more blood flows from it in a given time, than passed through it before in the same time to go to the capillary system, which resisted more. We cannot then judge of the velocity of the blood by the throw from the open arteries.

Sympathies.

We have seen that the arteries are rarely the seat of diseases either acute or chronic, on account of the ob-

scurity of their vital properties. They can exert then but a very slight influence upon the other organs; thus, except some sympathetic pains that are experienced in aneurism, this influence of the arterial texture upon the other systems is merely nothing. In two or three cases I have seen convulsive motions produced by the injection of a very irritating fluid in the arteries. It is easy to distinguish these sympathetic motions, from those that pain produces in an animal who is struggling to disengage himself; they are violent tremors or stiffness, like tetanus. It may be imagined that these experiments should not be made in the carotids, because the brain, irritated by the injected fluids, would produce convulsions arising from the stimulant that would be then directly applied to it, and not from a sympathetic relation. Besides, death would be the immediate consequence of the experiment, if it was made upon the carotid.

On the other hand, as the arteries have not sensible organic contractility, hardly any animal sensibility, and but little tone, the other organs can with difficulty develop in them sympathies by their influence; for, in order that a vital property should be brought sympathetically into action in a part, it is necessary that it should exist there, and even be conspicuous. Thus the innumerable variations of the pulse, which are the product of sympathies, have all essentially their seat in the heart; the arteries are not connected with them. Now the sympathies make the heart contract or arrest its motion, as stimulants or sedatives directly applied to it, that is to say, by acting on its sensible organic contractility. When an aneurism is broken in a fit of anger, or in the act of coition, a case of which I have seen with Desault, it is the motion of the blood, which is suddenly increased, that is the cause of it; it is not the arterial texture that has been affected by the passion. Besides, upon what can the sympathies act in the arteries? It could not be

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either upon the elasticity or the contractility of texture, the only properties, however, capable of contracting these vessels. Observe, also, that the sympathies put in action only the vital properties, because they are themselves a phenomenon purely vital. The physical properties and the properties of texture cannot be exercised under their influence ; this is an important observation.

Besides, as the arteries are every where spread in the organs, and as they form, if we may so say, a part with them, it would be difficult to distinguish what belongs to them, especially as it respects sensibility, from what is peculiar to these organs.

ARTICLE FIFTH.

DEVELOPMENT OF THE VASCULAR SYSTEM WITH RED BLOOD.

I. *State of this system in the Fœtus.*

The fœtus differs essentially from the infant that has breathed, in this, that its two great vascular systems in reality form but one, since the foramen ovale on the one hand, and the ductus arteriosus on the other, form a direct communication between the two. This communication is much more evident at the period nearest conception ; these openings contract towards the period of birth. 1st. The foramen ovale is formed, in the first months, by two productions in the form of a crescent, whose concave surfaces are opposite, and leave between them an oval space, which is constantly contracting, because these two productions constantly approximate and have a tendency to cross each other, which in fact takes place after birth. 2d. The ductus arteriosus contracts as the pulmonary artery dilates.

While these two openings are free, which is constantly the case in the fœtus, the two systems evidently make but one, as I have said ; whence it clearly follows that the blood that circulates there must be entirely of the same nature, that there cannot be two kinds in the fœtus, as there always is in the adult. This is, in fact, a remarkable difference between the two ages. 1st. I have many times dissected small Guinea pigs in the womb of the mother; their vessels have uniformly contained the same fluid, which is blackish, like the venous blood of the adult. This experiment is easy. The abdomen of the mother being divided, we successively open each of the separate sacs that the womb has for each fœtus. When one of these sacs is laid open, we cut the membranes, then the abdomen of the small animal, leaving the umbilical vessels untouched. The transparency of the parts easily allows us to see the uniformity of the colour of the blood of the vena cava and the aorta. The same remark applies to the superior parts. The carotid and jugular pour out the same blood when they are opened. 2d. I have three times made the same observation upon the fœtus of a dog. 3d. We know that the blood of the umbilical arteries is always black; all accoucheurs have remarked this. 4th. The change of the black blood to red arises from the contact of air in the lungs; the fœtus not breathing, cannot then have this kind of blood. 5th. I have dissected many fœtuses that have died in the womb of the mother; the blood of the veins and the arteries has appeared to me to be uniformly the same. It is true that this is not a very conclusive proof, since the mere standing of the red blood in the vessels, for a considerable length of time, is sufficient to make it black, as Hunter has observed.

The preceding facts are sufficient to establish incontestibly the uniformity of the blood in the two systems of the fœtus; an uniformity that exists at least in external

appearance, if it is not real in its intimate composition. It is for the chemists to elucidate this point.

How is it, that the instant the black blood enters the system of red blood in the adult, alarming consequences follow, soon asphyxia, then death, take place, whilst in the fœtus, the black blood circulates with impunity in the arteries? It is a difficult question to resolve, and yet these two contradictory facts are equally true. The difference of the nature of the blood of the fœtus might perhaps serve to remove this difficulty, if we better understood this difference. In fact, though the colour assimilates this blood with that of the veins of the adult, yet it does not appear to be the same; it has an unctuous feel, unlike the other. It is never found in the dead body coagulated like it, but always fluid, like the blood of those who have died of asphyxia. Fourcroy discovered no fibrin in it; he observed that it did not take the vermilion colour by the contact of the air; that it contained no phosphoric salts, &c. It is then very probable that if the black blood is fatal in the arteries of the adult, whilst it circulates with impunity in those of the fœtus, that it arises from the difference of the nature of the one and the other. Besides, observe that there is a very great difference in the functions of the fœtus and the adult. The first scarcely has animal life; it wants many functions of organic. The relation of the organs with each other, is of a nature wholly different from what it will be after birth. No kind of analogy ever can be established between the fœtus and the infant in this respect. Thus we have observed that the experiments upon life and death give a result wholly different in animals with red and warm blood, and in those with red and cold, which approximate nearly the organization of the fœtus in some respects. We cannot then establish any kind of parallel in respect to the injury of the respiratory phenomena, between the fœtus and the infant, an injury, the

causes of which I have sought in my experiments, since the organization relative to these phenomena differ so essentially in the one and the other.

Although, as I have said, the blood of the two vascular systems is confounded in the fœtus, yet there is, especially in the first periods, a kind of separation in the general mass of blood, a separation that was first accurately observed by Sabatier, and which is the result of the arrangement of the foramen ovale and the ductus arteriosus. This separation divides the mass of blood into two. The following is the manner in which the circulation of the blood is performed in this respect.

1st. All the blood that the trunk of the inferior vena cava receives, either from the capillary system of the inferior extremities, or from that of the abdomen, or from the placenta by the umbilical vein, instead of stopping in the right auricle, as in the adult, passes entire into the left through the foramen ovale, the superior edge of which is so arranged, that nothing can mix with the blood of the superior vena cava; so that when we examine attentively, we see that it is really with the left auricle that the inferior vena cava is continued. Hence why this auricle is in proportion as much dilated as the right; for it would be very contracted, if it had only to receive the blood of the pulmonary veins, the quantity of which is merely nothing in the first periods of life. From this auricle the blood passes to the left ventricle, which transmits it to the aorta, where it meets the carotids and subclavians, which, by numerous ramifications, carry it to the capillary system of the head and the superior extremities.

2d. After having remained in this system, the blood returns by the different branches of the superior vena cava to the right auricle, where the superior edge of the foramen ovale prevents it from communicating with the other blood; from this auricle it passes to the ventricle, which transmits it to the pulmonary artery, which sends

a small part of it that returns to the left auricle by the veins of the same name, but transmits almost the whole of it by the ductus arteriosus to the descending aorta, below the origin of the carotids and the subclavians, which carry the other blood. This is carried by the branches and ramifications of the aorta to the capillary system of the abdomen and inferior extremities; the remainder is afterwards carried by the umbilical artery and lost in the placenta.

It follows from what we have just said, that notwithstanding the continuity of the two great sanguineous systems in the fœtus, there is in the first months after conception, a kind of separation of the blood they contain; that there is even if we may so say, two systems wholly different from those which will afterwards exist in a separate manner in the adult.

The first of these systems has, 1st, for origin all the capillaries of the abdomen, of the inferior extremities, and even those of the placenta; 2d, for common trunks, below the inferior vena cava, above the quadruple branch called the aorta; 3d, for agent of impulse the left side of the heart; 4th, for termination all the capillaries of the head and the superior parts. The second commences in these last capillaries, and is composed, 1st, for its trunks, of the superior vena cava and the descending aorta; 2d, for its agent of impulse, of the right side of the heart; 3d, for its termination, of the capillaries of the inferior parts.

The blood is then evidently divided in the first months after conception into two circulations, which cross, if it may be so said, in the form of the figure 8, as has been remarked by Sabatier; it is carried in each, from one assemblage of capillaries to another of the same vessels. Only instead of moving between the pulmonary capillary system and the general one, as in the adult, it moves between the superior and inferior part of this last system; we may then say in this point of view that the inferior

and superior parts of the body are in opposition in the fœtus, as the lungs in the adult are in opposition to the rest of the body.

This complete opposition on the part of the circulation, between the upper and lower part of the body, in the first months of the fœtus, is probably the origin of the difference that takes place afterwards between these parts.

All physicians have observed this difference in diseases. If the median line frequently separates the affections of the right side from those of the left, the diaphragm seems often to be the boundary of many diseases. Who does not know, that scorbutic affections appear particularly below, that serous infiltrations are most frequent there, and that ulcers are infinitely more common in the inferior extremities, and that on the other hand, most cutaneous eruptions take place in the superior parts, &c.? Bordeu, who has said much of the division of the body into superior and inferior parts, considered one pulse as the precursor of evacuations from above, and another as that of those from below, he has however without doubt exaggerated this opposition of the two parts of the body; still it really exists, and I think that it is very probable, that the manner of the circulation of the fœtus is the primary source of it.

After the first months, things begin to change. The quantity of blood passing by the pulmonary artery was at first scarcely any thing, because the dilatation of the ductus arteriosus was so great, that it turned almost the whole of it into the descending aorta. This canal gradually contracting, the pulmonary arteries dilate, and then more blood goes through the lungs, and is brought by the pulmonary veins to the left auricle, which transmits it to the left ventricle, which sends it to the arch of the aorta; then the mechanism of the circulation described above begins to change, and approximate that of the infant, as we shall see.

Still this first mechanism predominates for a long time over the second; hence it happens that during the greatest part of the time that the infant is in the womb of the mother, it is the left ventricle that sends the blood to the superior parts, whilst the inferior receive theirs by the impulse of the right. Now as the parietes of the first are evidently thicker than those of the second, and the heart is further from the inferior than the superior parts, these last receive a stronger impulse than the others. This perhaps is a new source of the difference of the two halves of the body; hence nutrition is more active in that above, hence the degree of vital energy that it preserves a long time after birth, and which makes it susceptible, the head especially, of many more affections than the lower half.

As the period of birth approaches, the pulmonary artery sends more blood to the lungs, and less passes through the ductus arteriosus. For, as I have said, it is only in a gradual manner that the whole of this fluid, contained in the body, comes finally at birth to go through the lungs. Though before it undergoes no alteration there, it does not circulate the less, which is undoubtedly to habituate it to the passage that it is constantly to take after birth. The quantity of blood then is in a direct ratio to the age in the pulmonary artery, and in an inverse one in the ductus arteriosus.

This arrangement evidently requires a corresponding one in the foramen ovale; in fact, if in proportion as the ductus arteriosus contracted, this was not diminished also, all the blood would finally accumulate in the superior parts. For instead of passing from them to the inferior, the whole of it would return to them by the left auricle and the ventricle of the same side. In proportion as the ductus arteriosus is contracted, the foramen ovale being lessened also, the blood of the inferior vena cava, the whole of which cannot pass through there, begins to mix with that of the superior, enters the right auricle, then the

right ventricle, afterwards returns by the lungs to the left auricle and ventricle and the aorta. What is the consequence of this? that this artery begins to receive from the left ventricle a much greater quantity of blood than can pass into the carotids and subclavians; a portion of it then goes into the descending trunk and is distributed to the inferior parts.

From what has been said, it appears, that the two portions of the blood of the fœtus are almost wholly separate in the first months; all that comes from the inferior vena cava goes into the ascending aorta; all from the superior passes into the descending, the lungs receiving scarcely any except by the bronchial arteries for their nutrition. But as the period of birth approaches, these two portions of blood begin to mix, and the circulation then has an arrangement between that of the adult and that of the first months. At birth even, the foramen ovale and the ductus arteriosus are much contracted, the circulation goes on in the mother's womb almost in the same way as it does after birth; the whole difference is that the fluid is of the same nature, because respiration has not taken place. The sudden change of the circulation at birth, arises particularly from the introduction of red blood into the economy. As to the mechanical phenomena, they are gradually produced by the gradual contraction of the two openings of communication. The blood gradually ceases to move from the inferior to the superior capillaries; it then goes from both of these to those of the lungs. and reciprocally.

In considering the circulating phenomena, we err in supposing that their change is sudden at birth. It is sufficient to examine the foramen ovale and the ductus arteriosus at different periods of pregnancy, to see that they contract successively, and that consequently these phenomena are successive, so that if the fœtus should remain in the womb a long time beyond its period, and the contraction should continue in the foramen ovale and the ductus

arteriosus, the blood would circulate as in the adult, from the pulmonary to the general capillary system exclusively, and reciprocally. The only difference would be in the uniformity of its colour, because it would pass through the first system, without coming in contact with the air.

I do not say that the entrance of the air does not suddenly bring to the lungs the remainder of the blood which passed by the ductus arteriosus; but this kind of sudden turn takes place only in a part of the blood of the pulmonary artery; a part already passed through the lungs before birth, though the air cells were empty.

In general, there is a constant relation between the quantity of blood that the right ventricle sends to the lungs, and that which the left sends to the inferior parts. The more the first increases, the more abundant is the second; this last evidently exceeds that which goes to the superior parts. These three things, 1st, the quantity of the blood of the inferior vena cava which mixes with that of the superior, and passes with it into the right auricle; 2d, that which from the right ventricle goes through the lungs and returns to the left auricle; 3d, that which from the left ventricle goes to the descending aorta, constantly increase as the period of accouchment approaches.

The descending aorta does not undergo by these variations any change in its caliber; in fact, it is the same thing to it, whether it receives the blood of the ductus arteriosus, below the origin of the carotids and subclavians, or whether this fluid comes directly to it from the left ventricle, through its arch; its parietes constantly increase in a uniform manner; all depends upon the successive contraction of the ductus arteriosus and the foramen ovale.

The whole vascular system is generally remarkable in the fœtus for its great development. The arteries are in proportion larger, which corresponds with the size of the heart, which is much developed at this age; it is nearly the same as the nerves in relation to the brain.

The development of the arteries however is not like that of the nerves, nearly uniform every where. These vessels follow in general the same order as the parts to which they are distributed. Thus in the superior parts, the cerebral arteries are much more evident than the facial; among these, the ophthalmic is more so than the nasal, the palatine, &c. In the thorax, the thymic arteries are much larger in proportion than afterwards. In the abdomen, all the gastric viscera being very considerable, their arteries are already very large; the supra-renal are much larger in proportion than in the adult. In the pelvis on the contrary, the arterial system is very contracted, because the viscera are small, as they receive but little nourishment. In the inferior extremities, the arteries are a little more contracted in proportion than in the superior, especially in the earlier periods, for towards birth, the proportion is nearer equal.

The arterial texture is infinitely more pliable in the fœtus than in the adult; it will yield more easily to extension; ligatures applied upon the arteries break it less easily. Aneurisms are extremely rare in infants.

Many little arteries wind upon the parietes of the great ones in the fœtus; they are often livid, to see them distinctly, it is necessary, as I have said, to examine them at this age. Does this abundance of vessels dispose the arteries in the first age to inflammations, which are so rare afterwards? I have never observed this alteration.

In the first periods of the fœtus, the layers and arterial fibres are indistinct; we should say that the coat of the artery is homogeneous. But it has however much more consistence than most of the surrounding textures; this consistence corresponds with that of the heart. Destined to distribute every where the nutritive matter, the arteries ought necessarily to precede the other organs in their nutrition. This early growth, always concomitant with that of the heart, would alone prove that the arteries are made

to develop themselves, and that the heart does not hollow them out, as Haller has said, in the interior of our organs by the force of its impulse. Besides this mechanical manner of considering their formation is evidently contrary to the known laws of the animal economy.

II. *State of the Vascular System with Red Blood during growth.*

At the moment of birth, two great revolutions take place in the system with red blood; 1st, a mechanical one, if it may be so said, in the phenomena of the course of the blood; 2d, a chemical one, in the nature of this fluid. The mechanical revolution depends upon the entire cessation of the passage of the blood through the foramen ovale, the ductus arteriosus, the umbilical arteries and veins. The chemical revolution depends upon the formation of red blood. I will now examine this last.

The fœtus finds at birth that all surrounding objects are the causes of great excitement; the cutaneous surface, all the origins of the mucous, are strongly stimulated. The sensations they experience are even painful, because the difference is very great between the waters of the amnios and the bodies with which the fœtus comes in contact at birth, and every abrupt change in the sensations is painful. Habit soon familiarizes this sensation; but it is not less real at birth, and it may be said that this moment is as painful for the infant as the mother. Now, as every lively sensation is generally accompanied with great motions a general agitation succeeds the impression that the fœtus perceives from without; all the muscles move, the intercostals and the diaphragm like the others. The air which already filled the mouth and wind-pipe, then enters the lungs, and there colours the blood red, then it is alternately expired and inspired until death. The first inspiration then is, in this point of view, a phenomenon analogous to all the motions that the change of external ex-

citement suddenly produces at birth in the voluntary muscles of the fœtus.

The respiratory motion is, however, too important, since it commences a new kind of relation between the organs, to depend exclusively upon this cause. I presume that an unknown principle, a kind of instinct, induces the fœtus at the moment of birth, to contract the intercostals and diaphragm. This instinct, which I do not understand, and of which I cannot give the least idea, is the same that makes the infant the moment it comes from its mother's womb, contract its lips, as if to nurse. We certainly cannot say that this motion is an effect of the very acute external impressions that it feels; these impressions produce agitations, irregular motions, as if to get rid of these impressions, and not a uniform motion evidently directed towards a determinate object. If we examine all animals separately at the instant of their birth, we shall see that every one performs particular motions, directed by its instinct. The small quadrupeds seek the breast of their mother; the gallinaceous animals the grain that is to nourish them; the small carnivorous birds immediately open their bills, as if to receive the prey the mother is afterwards to bring to them in the nest, &c.

In general, it is essential to distinguish accurately the motions, which, at the instant of birth, arise from new excitements that the body of the fœtus receives, from those which are the result of a kind of instinct, of a cause of which we are ignorant. I believe that the respiratory motion belongs at the same time to the two causes, and more especially perhaps to the last.

I pass now to the mechanical revolutions of the course of the blood. At the instant the lungs change to red the black blood that enters them by the pulmonary arteries, they receive all that which before passed through the ductus arteriosus; this ceases to transmit any to the

aorta, though, however, it often remains still more or less dilated ; for at birth it is hardly ever entirely obliterated ; this contraction varies singularly at this period. Why does the blood then cease to flow there? As the aliments do not enter the ductus choledochus, the lacteal or pancreatic ducts, though they pass their orifices ; so undoubtedly this takes place, because the kind of sensibility of the ductus arteriosus repels the new venous blood of the fœtus, which comes no longer from the placenta, because that which the lungs have reddened will not mix with it. We cannot certainly give any mechanical reason for its not passing ; it really does not, and it evidently depends upon the vital laws. Besides, the motion of which the lungs become the seat, the dilatation, and especially the new excitement that the external air produces there, by rendering considerably more active the capillary circulation, facilitate that of the two pulmonary trunks, and give the blood a tendency to pass there rather than through the ductus arteriosus ; it is in this way that the lungs attract, as I have said, the blood from the pulmonary artery. Does not the great irritation, of which certain tumours are the seat, draw there more of this fluid ? Is it not on this account that the arteries of these tumours dilate and acquire a double or even treble caliber ? What takes place in these tumours in a gradual manner, happens suddenly to the blood that still passes by the ductus arteriosus at birth, and which was very much diminished, as I have said, by the successive contraction of this canal.

For the same reason that all the blood of the pulmonary artery goes through the lungs, the foramen ovale is closed ; in fact, this foramen is so arranged at birth, that its valves approximate so as to cross, as it were ; so that when they are pressed against each other, the communication of the auricles is really closed. Now the red blood entering the left auricle by the pulmonary veins, pushes the valve of the foramen ovale correspond-

ing to this auricle, against the other, and consequently opposes the blood of the vena cava inferior that endeavours to enter there. This blood flows back to the right auricle. Now when this contracts to drive the blood into the ventricle, far from forcing it through the foramen ovale, it necessarily brings the two valves against each other, and obliterates it. By examining with care the state of the heart of the fœtus, it is evident that when the blood enters the left auricle by the pulmonary veins, the right by the venæ cavæ and the valves are crossed, it is impossible that the blood can pass them either in contraction or dilatation.

Though the foramen ovale may be open at birth, still the black blood ceases to pass through it; I say further, oftentimes this foramen remains open during the whole of life. Many authors have related examples of this. I have seen a great number, though this assertion may appear extravagant at first. It is impossible from the arrangement of its two valves, for the blood to pass through it. When the two auricles contract at the same time, the blood which is forced by them from without within, brings the valves together, and thus itself creates an obstacle to its passage. In the greatest number of cases, the adhesion of the two valves crossed, is extremely weak; they are rather in contact than united; so that by forcing between them the handle of a scalpel, they are easily separated and hardly any traces of rupture are found. If they were arranged so that the blood could insinuate itself between them, it would soon separate them and re-establish the communication. Authors need no longer attempt to explain, how life is supported when the foramen ovale is open; it is the same as if it was closed, no more blood passes through it.

The obliteration of the foramen ovale, and the cessation of the passage of the blood through its opening, are, as we see, phenomena to a certain degree mechanical.

The vital laws perform also, without doubt, their part on this occasion. Who knows if the sensibility of the left auricle, stimulated and modified anew by the red blood, does not repel the black which tries to enter it by the foramen ovale? We see every day in the economy, fluids passing at the side of openings, without entering them, though they may be wide, for the sole reason that their sensibility is not in relation with these fluids. Why does the trachea convulsively reject all fluids and solids? why does the air alone enter it? Why does not the blood enter the thoracic duct, which is often furnished with a valve, as I have observed, incapable of opposing its passage, and sometimes even has none? Why does the urethra repel the urine in coition? It is a fault of all authors that they seek only for mechanical causes in all the phenomena of the circulation. Without doubt the course of the blood is a mechanical phenomenon; but the laws that govern this course are vital; it is the same as a bone that is moved by muscular contraction; the effect is the mechanism of the lever; the cause is vital.

The blood no longer passing through the ductus arteriosus, this closes immediately by its contractility of texture; it becomes a kind of ligament, which fixes to a certain degree the aorta and pulmonary artery in their respective position. As to the obliteration of the foramen ovale, it does not arise from this contractility; this obliteration is not made by a contraction, but by a real agglutination of the two valves, between which it is obliquely situated at birth. This agglutination appears to be the effect of a pressure that is made in an opposite direction, upon the partition between the auricles, by the blood that each contains. In fact their fibres are so arranged that they contract from without within; now by contracting thus, they press from each side the blood against the partition, and consequently the two valves against each

other. Now this agglutination sometimes does not take place, whilst the contractility is always exerted when the parts in which it exists cease to be distended; the ductus arteriosus is uniformly obliterated.

At the same time that the ductus arteriosus and foramen ovale cease to transmit blood at birth, this fluid is stopt in the umbilical artery and vein. Why does the blood cease to flow in this artery, though its diameter continues very large at birth? The principal cause appears to me to be the nature of the red blood, which is no longer in relation with the sensibility of this artery. A proof of this is, that if some time after the fœtus has breathed, respiration is stopt, and the black blood consequently returns, the umbilical arteries begin to pulsate, and if the ligature is loosened, they pour out considerable blood. Baudelocque has frequently observed this.

In general, when respiration is well established, the blood no longer flows by the umbilical artery, the ligature of the cord is then useless. On the other hand, when this function is badly performed, there is reason to fear hemorrhage of this artery. I confess, however, that there may be other causes for this interruption of the passage of the red blood. These four things, 1st, the cessation of the entrance of the blood into the umbilical vein; 2d, interruption of the passage of that of the inferior vena cava by the foramen ovale; 3d, of that of the pulmonary artery by the ductus arteriosus; 4th, of that of the descending aorta by the umbilical artery; these four things, I say, the three last especially, appear to depend upon a cause that we do not yet understand. The change of the relation of the organic sensibility with the nature of the blood, is perhaps only accessory, since, as I have observed, it is less this property than the action of the heart itself, which is the cause of the circulation in the trunks. This subject deserves the most attentive examination of physiologists.

Respiration being once well established, the lungs are in opposition to the whole body; it sends blood to all the parts, and they all send it to the lungs. The boundary is then rigourously established between the system with black blood and that with red, and things then go on as we have before described.

After birth the vascular system with red blood predominates for some time by its greater development and its more numerous branches. In fact the red blood enters more parts then than it does afterwards. It is sufficient to dissect living animals of different ages, to be convinced of the greater quantity of blood in young animals, that the system contains, of which we are treating; so that, as I have said elsewhere, the two opposite ages of life exhibit an inverse arrangement as it respects the fluids and solids. The first are much more abundant towards the period of conception. The second always predominate more towards the last age.

The predominance of the system with red blood remains evident to the end of the period of growth. We see the necessity of this predominance to distribute to all the parts the materials of their nutrition and growth; in fact, in the adult the arteries contain only what is destined to the first. In the infant, they contain moreover what is destined to the second. Hence the caliber of the arteries is proportionably larger than afterwards, in order to contain more fluid. Injections demonstrate this; and on this account small subjects are not less favourable for the study of the arteries, than of that of the nerves. These vessels are more prominent in them; only the surrounding parts being less developed, we cannot see the connexions so well.

In proportion as the infant advances in age, the equilibrium is gradually established in the system with red blood. In the head, the facial arteries are more evident, and come gradually in their development to the level of

the cerebral. In the thorax, the thymus diminishing as the lungs increase, their nutritive arteries follow an inverse order; the bronchials dilate and the thymic contract. In the abdomen less blood goes to the capsular arteries; but most of the others receive as much of it. The pelvis and the inferior extremities have more of it, and their development is proportionably evident.

III. *State of the Vascular System with Red Blood after growth.*

It is about the period of puberty that the increase in height ceases; the increase in thickness continues always. The genital parts, hitherto without influence, seem to be then a centre of more active vitality than most of the other organs. The portion of the system with red blood that belongs to them, then becomes greater. The first effect that results from it is the secretion of semen, and a general impulse of the individual towards new tastes and desires, towards those relative to the propagation of the species.

Another phenomenon is soon the consequence of this. As the lungs are connected in an intimate, though unknown manner, with the genital parts, they acquire also a predominance with them. Their vital energy is increased, and then begins the period of the affections of this viscus; then, the cause that would in the adult produce a gastric affection, brings on a pulmonary one.

It is truly only at this period, that the predominance of the superior parts, of the head especially, ceases entirely. Thus whilst in infancy the nose is frequently the seat of hemorrhage, in youth it takes place particularly from the lungs. We may consider the increase of the energy of the lungs, which happens shortly after puberty, as the termination of the predominance of the superior parts. The cutaneous eruptions of the cranium, tinea capitis, &c. cease to be as frequent. Convulsions, and all the diseases that arise from the extreme suscep-

tibility of the brain, become also more rare, and seem to give place to a great number of acute pulmonary affections.

It is towards this period, that is, some time after the end of the increase in height, that the diseases that are considered as the product of an arterial plethora, begin especially to manifest themselves; this may be said to be their age, and it arises from the following cause; as the blood contains before puberty, not only the materials of nutrition, but also those of growth, and whilst this continued the whole is expended in the system with red blood. But when the parts cease to increase in length, if this system still continues to receive the materials of growth, a true arterial plethora takes place. About the end of growth generally, some affections appear that indicate a predominance of the blood; as this is however under the influence of temperament, of the mode of life hitherto led, of the season and a thousand other causes, which, making the phenomena of the animal economy vary, rarely permit us to establish exclusive general principles. Thus all that is said upon the disposition to different diseases, in the different ages, &c. is subject to many exceptions.

The predominance of the lungs is gradually lost; the equilibrium is established among all the organs, which, hitherto had each performed a part more or less conspicuous in the phenomena relative to the different ages. As the system with red blood is uniformly, in every part, in proportion to its growth, to which it especially contributes, the equilibrium is in that way established between the different parts at twenty-six or thirty years of age; all the arteries have a proportional size, analogous to what they will always have afterwards. Whilst until then, some predominated, according to the predominance of the growth of the organs to which they are sent.

Towards the fortieth year, the gastric viscera seem to acquire a more decided vital activity; but this activity

has no influence upon the size of the arteries that are distributed to these viscera.

Though the growth in height may end about the sixteenth or seventeenth year, that in thickness uniformly continues; so that the internal viscera still grow, and their arteries consequently enlarge, until the last growth ceases. This phenomenon has constantly struck me, in comparing arteries injected in subjects from sixteen to twenty years, with those in subjects beyond thirty-six or forty. In the last they are uniformly larger. It is this difference that first gave me the idea of distinguishing growth, into that in height, and that in thickness. For the development of the arteries is the constant index of the state of the growth of the organs. The period of the cessation of growth in thickness is then remarkable, 1st, by the cessation of the increase of the caliber of the arteries; 2d, by the general equilibrium that is established in their development.

As the arteries grow in the years that succeed the end of the growth of the body, they increase in compactness and thickness. Their fibres become more evident; their elasticity increases; their pliability is lessened; hence why the age of the adult is that of aneurisms. Observe that the density of the arteries follows, in its augmentation, the same proportion as the fleshy fibres of the heart; so that as this is more able to send the blood with force, these are more able to resist it.

IV. *State of the Vascular System with Red Blood during old age.*

In the last years, the system with red blood is remarkable for the following phenomena.

The number of the arterial ramifications is much diminished. As the heart loses its energy, it sends less blood, and with less force. The general vibration that it produces in the whole arterial tree, is less felt at the extremi-

ties of this tree. The small vessels that form these extremities gradually contract, are obliterated and become so many little ligaments. Hence why, when the periosteum is separated from the bone, the dura mater from the internal surface of the cranium, only a few drops of blood escape; why the skin, having hardened like horn, no longer exhibits the rosy tint of the preceding ages, especially of youth; why the section of a bone does not furnish hardly any blood, whilst it was so abundant in the fœtus; why the mucous surfaces look pale, the muscles have a dull colour, &c. All anatomists know that injections succeed less in proportion, as the subjects are more advanced in years; that in extreme old age the trunks alone are filled; that the fluids never enter the ramifications; that it is the reverse in young subjects; that even coarse injections oftentimes so fill the ramifications, as to render dissection difficult. I have dissected many old living animals; and the small quantity of blood their vessels contain compared with those of young animals is very remarkable. The general proposition that I have established, viz. that the solids are constantly acquiring the predominance, is perfectly true. This obliteration of the small vessels is remarkable even upon the parietes of the great vessels; we see it in the dead body; I have observed it in the living.

The less quantity of red blood that is found proportionably in old age, is referable especially to the state of nutrition, which is merely nothing when compared with that of infancy. Observe also, that united with the weakness of the motion that animates the blood, it is a cause of the small degree of excitement which the parts have in old age. In fact the use of the circulation is not only to carry to the different parts the materials of the secretions, of exhalations, nutrition, &c. we shall see that it keeps them also in a state of constant excitement by the shock it gives them at its entrance, a shock, the principle of

which is evidently in the heart. Now this shock is in a ratio compounded, 1st, of the quantity of the fluid; 2d, of the force with which it is sent. In both respects, the excitement constantly diminishes, as age advances. Observe also that all the functions of the infant, both organic and animal, are characterized by a vivacity and impetuosity that form a remarkable contrast with the slowness and want of energy of those of old people.

The arterial texture always becomes more and more condensed as age advances. The layers that form the fibres of the peculiar membrane become drier, if I may be allowed the expression.

I have said that the internal membrane is very often the seat of a kind of peculiar ossification, which has hardly any influence upon the circulation, except when it is seated at the origin of the aorta.

The caliber of the arteries does not dilate in old age. There is scarcely any except the arch of the aorta, which constantly undergoes an enlargement more or less considerable, which is always without rupture of the fibres, consequently supposes an extensibility of these fibres, and undoubtedly depends upon the habitual and direct impulse that the blood exerts against the concave side of this curvature. I have often examined to see if there was a similar dilatation at those places in the arteries where the curves are very evident, in the internal carotid, for example, at the place where it passes through the carotid foramen; I have not discovered any.

In the last periods, the pulse is remarkable for its extreme slowness; a phenomenon opposite to that of infancy, in which the blood moves with great quickness. These two opposite facts are, after what we have said, foreign to the arteries. They indicate only the state of the forces of the heart, which is the agent of the general impulse of the red blood.

It is the same of the pulse in the last periods of life. It is not a real pulsation of the arteries; it is a kind of undulation, of weak oscillatory motion, and the more obscure, as life is more feeble. Now I am convinced that the heart alone is the agent of this undulation; I am convinced of it by the following very simple experiment. I have laid bare in many dogs, on one hand the carotid, on the other the heart by a section of one side of the thorax, made in such a manner that the other can still perform respiration. By placing the finger upon the artery, I observed that as long as the heart beat by a sudden impulse, that the pulse was kept up as usual, that it was even accelerated, because the contact of the air increased the quickness of the contractions of the heart; but at the end of a little time, this organ began to be weakened in its motions, then it contracted by a kind of general tremor of its fibres. In proportion as the weakness of the motions of the heart increased, the pulse was successively weakened. Then when the tremor extended to all its fibres, the pulsation of the artery changed to a kind of undulation, of feeble oscillation, the precursor of the cessation of all motion.

I shall observe, under the system of the muscles of organic life, that the heart has many kinds of contraction. The principal are, 1st, that which it ordinarily has, in which there is a contraction and a dilatation that succeed suddenly and regularly; 2d, that in which these two motions, retaining their natural character, are irregularly connected; 3d, those in which the fibres only oscillate, and by which the cardiac cavities a little contracted, communicate to the blood a less sudden shock, a general tremor, an undulation, &c. Now with each kind of motion of the heart, there is a peculiar pulse that corresponds. It is easy to be convinced of this upon living animals.

I am astonished that authors who have disputed so much upon the cause of this phenomenon, have not

thought of having recourse to experiment to elucidate the question. There are undoubtedly many modifications in the pulse, whose coincidence with the motions of the heart could not be perceived; but that of the slow and frequent pulse, the strong and weak, the intermittent, undulatory, &c. can be immediately discovered, by laying the heart bare and placing the finger at the same time upon the artery. We see then uniformly, during the moments that precede death, that whatever may be the modification of the arterial pulsation, there is always an analogous modification in the motions of the heart; this certainly would not be the case, if the pulse depended especially upon the vital contraction of the arteries. I have had occasion to make these experiments many times, either directly for this object, or with others in view; I have seen the motion of the heart always correspond with that of the arteries. In general the theory of the pulse requires as I have said, new researches; but I have facts enough upon this point to be convinced that the varieties it undergoes in the different ages, as under other circumstances, depend almost exclusively upon the heart, which produces in particular this kind of undulation, of oscillatory motion which is between the pulsation of the natural state and the complete cessation of this pulsation.

V. *Accidental development of the System with Red Blood.*

I shall speak under the organic muscles, of the accidental development of the left portion of the heart. As to the arteries, new ones are never formed; but oftentimes, those that do exist acquire a remarkable size; this depends on two causes, 1st, on an obstruction to the course of the blood; 2d, on the growth of any tumour.

1st. The dilatation of the arteries by an obstruction to the circulation, is evident in the ligature of aneurismatic arteries, in the spontaneous cure of aneurisms, a phenomenon of which within a few years a great number of ex-

amples has been published, &c. Then, sometimes the great collaterals increase in size, sometimes their caliber remains the same, and it is by the ramifications that the communications are made. As the branches dilate, their thickness increases in proportion with their breadth; at least I have twice observed this fact, which is analogous to that which the left ventricle presents when it becomes aneurismatic.

2d. All tumours do not produce a dilatation of the arteries; we see this dilatation in cancers, in those of the breast, of the womb, &c. in osteo-sarcosis or spina ventosa, in the different fungi, &c. In general, most tumours that give great pain to the patients exhibit this phenomenon. We should say even that pain in a part is sufficient to attract there habitually more blood, and dilate the arteries; we know that in the operation for lithotomy, when the patients have previously suffered much, hemorrhage is often more to be feared.

After long and copious secretions or exhalations, I have not observed that the arteries were more dilated in the glands or around the exhalant organs. How large soever the cysts may be, their parietes never contain arteries proportioned to those that are developed in cancerous tumours. The cerebral in hydrocephalus, the mediastinal, intercostals, &c. in hydro-thorax, the mesenteric, the lumbar, the stomachic, the epigastric, &c. in ascites, the spermatic in hydrocele, the renal in diabetes, the branches that go to the parotids after a long salivation, retain their ordinary size, and under some circumstances they become even smaller.

When the arteries dilate in tumours, do their parietes thicken in proportion, as in the preceding case? I have no data, from which I could determine this point.

VASCULAR SYSTEM

WITH BLACK BLOOD.

THE red blood circulates in a single system, the branches of which every where communicate. The black blood on the contrary is contained in two separate systems, which have nothing in common but the form, and which are, 1st, the general system; 2d, the abdominal. We shall now examine the first, and afterwards the second.

The general vascular system with black blood arises as we shall see, from the whole of the great capillary system, is collected towards the heart in great trunks, and terminates in the pulmonary capillaries. As the portion of the heart that belongs to it will be examined hereafter, and the pulmonary artery, by its peculiar membrane, has great analogy with the peculiar membrane of the other arteries, we shall now particularly examine the veins; but we shall describe in a general manner, the common membrane that is spread upon the whole system with black blood.

ARTICLE FIRST.

SITUATION, FORMS, DIVISION AND GENERAL ARRANGEMENT OF THE VASCULAR SYSTEM WITH BLACK BLOOD.

WE shall now examine the veins as we have the arteries, in their origin, course and termination. Only we shall do it inversely, to accommodate our ideas to the course in which the blood flows in their channels.

I. *Origin of the Veins.*

This origin is in the general capillary system. I shall point out in this system, how the veins are continued with the arteries. I would only remark here that these vessels never arise from any organ that the arteries do not enter, as the tendons, the cartilages, the hair, &c.; which evidently proves that the blood is not formed in the general capillary system; it leaves there the principles that made it red, it perhaps acquires there new ones; it is modified in fact, but never created.

It is not as easy to distinguish accurately the veins at their exit from this system, as it is the last arteries at their entrance into it, because the valves prevent injections from penetrating so far. It is in subjects that have died of asphyxia, apoplexy, &c. that the venous ramifications can be best observed. We see then that they are soon divided into two orders; one accompanies the last arteries, the other is distinct from them.

In the greatest number of organs, venous branches go out at the same place that the arteries enter. There are however some exceptions to this rule. In the brain, for example, the arteries enter below, the veins go out above. In the liver, the first enter below, the others go off behind, &c. This circumstance is, in general, indifferent to the circulation, which goes on the same whatever may be the relation of the arteries with the veins. In those places where the small veins go out at the same time that the small arteries enter, sometimes more or less of cellular texture serves to unite the small vessels that are in apposition, sometimes there is a space between them, as in the muscles, the nerves, &c.

Besides the venous origins corresponding with the arterial terminations, there is an order of veins which is separated from the arteries at the exit from the capillary system. This order is particularly remarkable at the ex-

terior of the body. We see that all the organs that are found there furnish, 1st, veins that go to the interior to accompany the arteries; 2d, others that go to the exterior to become sub-cutaneous, and to form trunks of which we shall soon speak. In many internal organs, the same venous division is observed.

It follows from this general arrangement, that many more veins go from the capillary system than there are arteries that enter it. This is the principle of the disproportion of the capacity existing between the system with red blood, and that with black, a disproportion of which we shall soon speak.

The veins at their origin frequently communicate among themselves. We see many little spaces that arise from their interlacing, in the places where they can be seen, as under the serous surfaces, &c.

II. *Course of the Veins.*

At their exit from the general capillary system, as we have just said, the veins are differently arranged. 1st. In the extremities and external organs of the trunk, they form two sets, the one interior, which accompanies the arteries; the other exterior, which is sub-cutaneous. 2d. In the internal organs we frequently make a similar observation; thus there are superficial veins of the kidney, and deep ones, that accompany the arteries; but oftentimes all the veins unite themselves to those that follow the artery.

The cutaneous portion of the veins is very remarkable in the extremities, where there are considerable branches, viz. the saphena in the lower, the cephalic, basilic, and their numerous divisions in the superior. In the trunk and the head, we do not see any great sub-cutaneous branches, except the external jugular in the neck; but there is a number of smaller branches proportioned to the minuter ones that are distributed there.

The external parts, then, are remarkable by the predominance of the trunks with black blood over those with red. Oftentimes these trunks can be traced through the integuments, upon which they show themselves much more than those that are whiter and more delicate; they have, besides, no connexion with the tinge that colours them, which arises from the blood contained in the general capillary system.

In the interior of the body, the veins almost every where accompany the arteries; they follow the same distribution; so that they are not commonly described, because the course of the arteries is sufficient to represent theirs. Usually a common cellular space receives both the trunks of the two sorts of vessels and those of the nerves. Sometimes, however, the veins are separate, as the azygos, for example, which has no corresponding arterial trunk, and which on this account requires in descriptive anatomy, like the superficial ones of the trunk and the extremities, a particular examination and an accurate dissection to obtain an idea of it.

The deep-seated veins have a caliber much more considerable than that of the arteries; most usually they are more numerous, as in the extremities, where each artery is almost always accompanied by two veins.

III. *Proportion of the capacity of the two systems with Black and Red Blood.*

After the observation I have just made upon the origin and course of the veins, it is evident that their sum total has a capacity much greater than that of the arteries. This assertion it is easy to prove in detail, wherever there is an artery and vein united, as in the kidneys, the spleen, the extremities, &c.; where the arteries are separate from the veins, as in the brain, the liver, &c. it is not less sensible. Finally, there is, as I have just said, a

division of sub-cutaneous veins, which is evidently one more than the arteries have.

Many physiologists have endeavoured to calculate the relation of capacity between the two systems with black and red blood; but this relation varies too much ever to be the subject of any calculation. Is it upon the dead body that the attempt is made? But the veins will be more or less dilated according to the kind of death; in apoplexy, asphyxia, drowning, &c. they have a diameter almost double that which they exhibit when the subject has died of hemorrhage, because the first kind of death accumulates much blood in the veins, and the second deprives them of it. We can give a greater or less capacity to the veins of an animal, according to the manner in which we kill him, as we can enlarge or contract the right cavities of the heart by similar means. You can never find the veins exactly equal in any two subjects, though there may be a great resemblance as to size, age, &c. Is it upon a living animal that the attempt is made? But, besides its being very difficult, you will not then have a result uniformly applicable, because the veins vary in diameter as they are more or less full. Examine these vessels in subjects in whom you can see them by the transparency of the integuments; sometimes they are more, sometimes less apparent; their size sometimes appears double, at others, hardly distinguishable. Certainly after drinking copiously, by which the black blood has received a great augmentation of its fluid, the vessels are more dilated than in an opposite state. The veins are remarkably contracted after death from hunger. I have often observed the same phenomenon in dropsics, phthisis, marasmus, &c. Always when the mass of blood is diminished, the veins contract by their contractility of texture. The arteries are infinitely less subject to variations of diameter, on account of their firm and compact texture, though, however, they show much of it.

Let us reject, then, every kind of calculation upon the proportions of capacity of organized canals. We can only calculate what is fixed and invariable; but that which varies at every instant can only be the object of general assertion. Besides, of what importance are the rigorous proportions that some physicians have endeavoured to establish between our parts? They are nothing in the explanation of the phenomena of health and disease. Let us, then, be content with this general assertion, that the venous capacity surpasses the arterial. It may be said, that in a given time there is more blood in one than the other.

The same observation applies to the two sides of the heart, one of which belongs to the same system with the veins, and the other to the one with the arteries. The right has commonly a greater capacity than the left, not precisely under the relation of the fleshy texture, but under that of the fluid that distends it; this is so true, that if in an animal whose thorax is opened, the blood is made to accumulate in the left side by ligatures, and the right is emptied by puncturing it, the last will be less in size than the first. Always when we find it larger than the other in the dead body, except in diseases of the heart, it is because it contained more blood at the moment of death; in fact, as this fluid ordinarily stops first in the lungs, it flows back to this side of the heart, which is almost always the largest.

This is the great difference between inert cavities and those that possess life, viz. that these last can change their capacity every moment, whilst the others remain always the same. In the living animal, the right side of the heart has almost always a greater capacity than the left, because the quantity of blood it contains is greater.

There are, then, two things generally true, viz. 1st, that the great tree that terminates the system with red

blood is in general of less capacity than the great tree that commences the system with black blood; 2d, that the same observation is applicable to the two sides of the heart, which correspond with these two trees.

As to the tree that terminates the system with black blood, compared with that which commences the system with red blood, the same thing does not hold true. The pulmonary artery and the veins of the same name exhibit a disproportion of capacity, less it is true, than in the other parts, a disproportion which is real, however, and which, notwithstanding what many authors have said, is in favour of the veins. How does this happen? it would seem that since the one is continuous with the veins and propels the same fluids, it ought to have the same proportion of diameter; and that since the others are continuous with the arteries, that they also should be in proportion to them. This arises from the difference of the velocity of the blood; in fact, this fluid circulates quicker in the pulmonary artery than in the veins of the same name, since it has the impulse of the heart, which these last want; then, in a given time, as great a quantity of blood passes through it, though the diameter of this artery is smaller; what do I say? if it was equal, the circulation could not go on. In the same way, if the aorta equalled in capacity the two venæ cavæ and the coronaries united, and the blood had the same velocity there, the circulation would cease.

The four pulmonary veins united are a little larger than the aorta, which, however, transmits all the blood received from them. Why? Because the impulse that the left ventricle communicates, makes, in a given time, more blood pass by the aorta than by the four pulmonary veins. These two things, 1st, the velocity of the fluid; 2d, the capacity of the cavities in which it circulates, are then in an inverse order in the two opposite trees that form each vascular system. In that with red blood, there

is less velocity and greater capacity from the pulmonary capillary system to the agent of impulse; and from this agent to the general capillary system, there is, on the contrary, greater velocity and less capacity. In the vascular system with black blood, there is less velocity and greater capacity from the general capillary system to the agent of impulse; and from this agent to the pulmonary capillary system, there is more velocity and less capacity. Without this double opposite arrangement, it is evident that the circulation could not take place.

There is, however, a remark to be made upon this subject; it is, that the capacity of the four pulmonary veins united, is not so much larger than the aorta as that of the venæ cavæ and the coronary is than the pulmonary artery; and this is the reason of it; as the pulmonary veins run a very short course, the impulse, on the one hand, that the red blood has received from the pulmonary capillary system, is preserved there more; on the other hand, this fluid is there free from numerous causes of delay that the blood experiences in the venæ cavæ and coronaries; then the velocity is greater there, and the capacity should be therefore less. If the lungs were situated in the pelvis, the pulmonary veins would certainly have a greater capacity, because having a greater extent to go over, the velocity of the blood would be more retarded.

We can easily understand now the cause of many arrangements that have engaged the attention of anatomists; viz. 1st, why the sum of the arteries coming from the aorta has less capacity than that of the veins going to the right auricle; 2d, why the four pulmonary veins surpass also in diameter the artery of the same name; 3d, why these four veins are not exactly in proportion with the aorta, which is really a continuation of them; 4th, why the venæ cavæ and coronaries are so disproportioned to the pulmonary artery, which is, as it were, their continuation.

If there was no agent of impulse in the two systems with red and black blood, their capacity would be every where nearly the same, because the velocity of the fluid would be every where nearly the same. This is precisely what happens in the system with black abdominal blood, in which the hepatic portion of the vena porta is nearly as large as the intestinal one, because there is no heart between the two.

The velocity is less in the general veins and in the pulmonary, because they have not at their extremity an agent of impulse; we see there only a capillary system. The opposite reason explains the velocity of the course of the blood in the general arteries and in the pulmonary. We have seen in the preceding system, that the presence of an agent of impulse at the origin of the two great arteries, requires there a considerable resistance of this texture, whilst the absence of this agent requires but little resistance in the veins.

We see, then, clearly, why these three things, 1st, weakness of the parietes; 2d, slowness of the motion; 3d, great capacity, are the attributes of the veins with black and red blood; why these three opposite things, 1st, strength of the parietes; 2d, velocity in the motion; 3d, less capacity, characterize the arteries of both sanguiferous systems.

We see also from this why, though the red and black blood form in their whole course a continued column, though the common membrane over which they pass may be in the whole extent of each system nearly the same, the organs exterior to this membrane are, however, very different.

The inverse ratio of the velocity of the motion with the capacity of the vessels, appears to me so evident, that we might be able to judge nearly by the inspection of the vessel of the velocity of the blood that runs through it, if many causes did not, as I have said, make

the vascular parietes vary at the moment of death. We know that all the causes that lessen in the veins the velocity of the blood, increase their capacity; it is thus that we make them prominent by ligatures; that pregnancy enlarges those of the inferior extremities, that long-continued standing produces the same effect, &c.

It is to the same reason that must be referred the explanation of the following phenomenon; viz. that the relation of the arteries and the veins is not every where the same; thus the renal, bronchial, thymic veins, &c. are in general smaller in proportion to their arteries, than the veins of the spermatic cord in proportion to the artery of the same name, than the hypogastric veins in proportion to the corresponding artery. The blood has less difficulty in circulating in the first than in the second, where it rises against its weight; hence why the veins of the inferior parts, especially at a certain age, surpass their arteries more in diameter, than those of the superior parts exceed theirs.

Ramifications, Small Branches, Branches, Angles of Union, &c.

The veins present in their course, as it respects branches, smaller branches and ramifications, an arrangement analogous to that of the arteries, except that it takes place inversely. The ramifications are nearest the origin; they soon unite into smaller branches, these into branches, and these last into trunks.

The ramifications and most of the small branches are found in the interior of the organs. The first make an integral part of these organs, and are between their fibres, &c.; the second lie in their great interstices; in the glands between the lobes, in the brain, between the circumvolutions, in the muscles between the fasciculi, &c.

In going out of the organs, the small venous branches run into the branches, which take, as we have seen, two

positions, one sub-cutaneous, the other deep. The sub-cutaneous branches go in the extremities between the aponeurosis and the skin, in the trunk between this and the cellular layer that covers the muscles. The deep branches lie in the interstices that the organs have between each other, accompanying almost every where the arteries. The cerebral branches have a peculiar arrangement; they are placed in the interstices of the dura mater, and form with them what are called sinuses.

The venous branches differ from the arterial in this, that they are infinitely less tortuous; this is remarkable under the skin and in the interstices of the organs. This is a reason that would prevent locomotion, supposing that there was an agent of impulse at the origin of the veins, and that their parietes were not so loose. Hence a series of arterial tubes is really longer than a corresponding series of venous tubes; this facilitates the motion of the black blood, which has a less extent to go over, and which besides would find causes of delay in the curvatures, greater than the red blood, because this is driven by a strong agent of impulse, and the other is not.

The venous branches unite to form a certain number of trunks that are connected with those that are immediately discharged into the right auricle; these trunks are the internal jugulars, the iliacs, the azygos, the subclavians, &c. They are still less tortuous than the branches; they have, like the arterial trunks, deep positions, far from external agents, from which many organs defend them, as a hemorrhage from them would be followed with serious consequences.

The trunks, branches, smaller branches and ramifications do not always arise necessarily from each other, in the manner we have just pointed out. The branches are often united to the trunks, the ramifications to the branches, &c. &c.; as it is with regard to the arteries.

The angles of union vary; sometimes they are right angles, as in the lumbar, renal veins, &c.; sometimes they are obtuse, as in some of the intercostals; most commonly they are acute.

The arrangement of the smaller branches and the branches is as variable at least in the veins as in the arteries; they partake, in this respect, of the general character of irregularity that the organs of internal life exhibit. It is necessary only to attend to the general position and distribution of the branches, smaller branches, &c. Their union with the trunks and among themselves, is different in almost every subject.

Forms of the Veins.

The same observation may be made upon the forms of the veins as upon those of the arteries.

1st. A trunk, branch, &c. are cylindrical, when examined in a space where they receive no branch. In the dead body they appear flat, which arises from the collapse of the parietes, and this is owing to the absence of blood. But by distending them with air, water, &c. they take their primitive form. In the living body they appear round.

2d. Examined in a considerable extent, a venous branch appears conical, so that the base of the cone is towards the heart and the apex towards the general capillary system. This form arises from the smaller branches, that are successively united to this branch, and increase its capacity as it approaches the heart.

3d. Considered as a whole, the venous system represents three trunks; one corresponds with the vena cava superior, another with the vena cava inferior, and the third with the coronary vein; these three trunks have their apex at the auricle and their base at the general capillary system. Anatomists thus represent the whole of the veins, because the sum of their divisions, like the arteries,

has a greater capacity than the trunks from which these divisions arise.

There is however an observation to be made upon this subject, and that is, that the relation between the trunks and their divisions is not as exact in the veins as in the arteries; thus the sum of certain divisions considerably surpasses their trunks, whilst this relation is infinitely less in other cases. But all this arises still from the extreme variation of the venous parietes, according to the quantity of blood they contain; thus in dead bodies, sometimes the branches are much dilated by this fluid, and the trunks remain the same; sometimes an opposite phenomenon is observed. 1st. This last takes place especially when the lungs are obstructed; then in fact the blood flows back to the right cavities of the heart, then into the great corresponding venous trunks; these are then almost equal in capacity to the divisions they furnish, sometimes they even surpass them. 2d. When in the living subject, a limb has been situated for a long time perpendicularly, when standing has been long continued, for example, then the branches are more dilated than the trunks. Now as these causes of dilatation vary ad infinitum, the dilatations themselves are very variable.

From these varieties in the dilatation of the venous branches and trunks separately, it is evident that the relation existing between them is extremely variable, that it is affected by the manner of the death, by the diseases that have preceded it, by the habits of the subject, &c. Let us disregard then, upon this point, as upon every other, all calculations, even if they have a solid basis, if they do not lead to a useful result.

Injections are also a deceptive means of estimating this relation; in fact, they dilate the trunks much more than the branches, and especially than the smaller branches. The internal jugular injected, for example, becomes of an enormous size when compared with the sinus that empties into

it. The two venæ cavæ, the azygos, the subclavians, &c. dilate a little less than the jugular; but their size however is remarkable when they are injected, in comparison with that of their branches injected.

Anastomoses.

The veins communicate in general more frequently than the arteries. 1st. In the ramifications there is a real net work, the anastomoses are so numerous. 2d. In the smaller branches, they are not so frequent. 3d. In the branches, they are still less numerous; but still we find many of them, and it is this that particularly distinguishes these branches from the arterial, which are almost always separate from each other.

The communications between the branches of the veins unite immediately in an evident manner the cutaneous to the deep division; thus there is a communication between the cerebral sinuses and the temporal, occipital veins, &c.; between the external and internal jugular by one and even two considerable branches; between the basilic, cephalic, and their numerous divisions spread upon the fore arm, on the one hand; on the other, the brachial, the radial and cubital, by different branches that penetrate deep into the muscles; between the saphena and crural, tibial, peroneal, by analogous branches.

Though separated, the two great venous divisions can then evidently supply the functions of each other by mixing their blood. Hence why, 1st, by agitating the muscles of the fore arm, we increase the throw of blood in venesection, though the muscles do not furnish many branches to the open vein, which then receives the blood from veins, from which it is forced out by the muscles; 2d, why in external pressure that obstructs or even entirely stops the motion of the superficial venous blood, the circulation continues as usual; why, for example, if a ligature is left for a long time applied to the arm, the su-

perficial veins at first swelled, gradually become empty, by pouring their blood into the deep ones; why, notwithstanding tight bandages in fractures and luxations, the venous blood returns as usual to the heart, though it passes in less quantity by the superficial veins. 3d. If a strong band is applied high up on the leg, and the saphena vein is injected below, it does not fill above the band, but the injection goes into the crural. In the same manner the internal jugular may be filled by the temporal, &c.

The anastomoses between the superficial and deep veins are more necessary in man than in any other animal, on account of his clothing, by which the neck, the ham, the arms, &c. are subjected to compressions that would be dangerous without these anastomoses. We can say that upon them alone is founded the possibility of a variety of modes in clothing. That they show in fact that these modes are less dangerous than some physicians have thought; that the danger of apoplexy from a tight cravat, of varices from tight garters, &c. is much less than they have said.

When a single trunk is compressed, the blood passes easily into the neighbouring ones; but if the compression is made upon all the trunks of a limb, a certain time is requisite for this fluid to dilate the anastomoses. It experiences, before this dilatation takes place completely, a kind of stoppage in the capillary system, a stoppage that explains the momentary redness of the fore-arm in women, when the arm is covered with too tight a sleeve, that of the hand or the foot when the bandages of the fore-arm or the leg are too tight.

The mode of the venous anastomoses is very analogous to that of the arteries. Sometimes the smaller branches anastomose with the trunks, sometimes the trunks communicate among themselves.

In the last mode, 1st, there is merely a branch of communication, and this is the most common case; we see

this between the jugulars, between the deep and superficial veins of the thigh, the arm, &c. 2d. Two branches unite by their extremities and form an arch, the mesenterics afford an example of this. 3d. Sometimes instead of a trunk, there is an interlacing of the smaller branches that form a real venous plexus; such as that which surrounds the cord of the spermatic vessels.

In general, where there are the most obstacles to the blood, there the anastomoses are the most numerous. Hence why the veins that surround the spermatic cord communicate so frequently together, why the smaller branches of the hypogastric vein which are spread in the bottom of the pelvis, form there a plexus so extended, that it is a real net work in which the course of no one branch can be traced, so numerous are the communications. Notwithstanding this, these two portions of the venous system are the frequent seat of varices; they are even found more frequently dilated in the dead body on account of the difficulty the blood experiences there in rising against its own weight.

This leads us to a general reflection upon the venous system in relation to the anastomoses, and that is respecting the necessity there is for the communications being more numerous in this than in the arterial system. In fact, if we compare the course of the black blood with that of the red, we shall see that there are many more causes to modify that of the first.

The black blood evidently obeys its weight in certain cases. 1st. If we remain standing a short time the veins swell, especially after diseases in which the forces have been diminished; this swelling soon disappears if the leg is inclined; it increases if it remains perpendicular. 2d. There are many cases, in which the forces being very weak, the circulation cannot go on in perfection, except the legs are in a horizontal or inclined position. The influence of position upon many tumours and ulcers of the

legs is undoubted. 3d. We know that the first effect of the attitude with the head reversed, is a giddiness produced by the difficulty the blood experiences in rising against its weight. 4th. The valves are particularly destined to counteract the effect of gravity.

Every violent motion communicated to the black blood, and independent of gravity, can also disturb the course of this fluid; it is thus that when we move violently in a circular direction, the venous cerebral blood receives, if we may so say, a centrifugal motion, which, turning it from its natural direction, and preventing it from going entirely to the heart, produces a stoppage of it, and hence the dizziness that is experienced.

It is not only gravity and every other external cause of motion, which influence at every moment the motion of the blood in the veins, but there are also external and internal pressures, and a variety of other mechanical causes.

On the contrary, that of the arteries is independent of most of the causes, of weight especially, and of the internal motion. Why? because the rapidity of the motion is so great which the heart gives to the red blood, that the influence of gravity and every other analogous cause is necessarily nothing. Let us take a comparison; the greater the force with which a projectile is thrown into the air, the less influence the weight has in making it deviate; in the case of the blood its influence is still less. If the blood was driven in empty vessels, gravity would have some effect in the arteries; but in the sudden shock impressed upon the whole fluid that fills them, a shock, the effect of which is felt at the extremities at the same time as at the origin, it is evident that its effect is nothing. For an opposite reason, we can understand why it is so powerful in the veins, in which there is no agent of impulse, in which the parietes and capillary system alone produce the motions, where the motion is consequently slow, &c.

From these considerations, it is easy to see the reason of the very different arrangement that the arteries and veins exhibit in their branches, as it respects anastomoses, which are as rare on one side as they are frequent on the other.

IV. *Termination of the Veins.*

The veins terminate by two principal trunks, the superior and inferior venæ cavæ. There is also another, viz. the coronary vein, which empties separately into the right auricle; but as this trunk only brings back the blood that went to the heart, we shall pay but little attention to it in our general remarks, and but little to those small venous branches that empty separately from it into the same auricle.

Some authors have thought, that the two venæ cavæ were continuous and formed but one vessel; but it is easy to see how different their direction is. It is particularly in the fœtus, that their separation can be well perceived, since one corresponds with the right auricle, and the other with the left. There is behind the right auricle a kind of continuity of the membrane between the one and the other; it is the membrane of the black blood that is common to them, and which passes from the inferior to the superior; but in this respect there is no more continuity between them, than between the right side of the heart and the pulmonary artery, between the left and the aorta, &c.

By considering the whole of the trunks and the branches as a cone, we can say that there are two great venous cones distinct from each other; one for all the parts which are above the diaphragm, the other for all those that are below it.

The superior vena cava does not answer, then, entirely to the union of the arteries that form the aorta of the same name, which is only destined to the neck, head, and

superior extremities, whilst the other belongs moreover to the chest by the vena azygos. For a contrary reason, the descending aorta has a destination much more extended than the inferior vena cava.

The limit between the two cones of the ascending and descending venæ cavæ, is placed at the diaphragm. It is especially in this respect that we can say that this muscle divides the body into two parts. Has not this arrangement some influence upon the difference that is observed in certain diseases between the superior and inferior parts? Should not this cause be connected with those pointed out under the article upon the fœtus? As yet there is nothing certain with regard to this, but I think it not improbable.

Though forming each a distinct cone, the two venæ cavæ communicate, however, especially in the neighbourhood of their common limit, that is to say, in the neighbourhood of the diaphragm; the azygos is the great means of communication. We know, in fact, that its trunk opens into the right renal, into the vena cava itself, or into some of the lumbar veins, and that the semi-azygos that arises from it, goes also to the left renal or to the lumbar of the same side. This anastomosis is very important; physicians have not paid sufficient attention to it. It proves that when an obstacle is situated in the trunk of the inferior vena cava, a great part of the blood of this trunk can flow into the superior. Much has been said of the compression of this trunk by the enlargements of the liver, in the production of dropsies. But, 1st, it is ascertained by the numerous examinations of dead bodies in modern times, that the production of these diseases belongs to every kind of organic affection; that the lungs, the heart, the womb, the spleen, &c. can likewise occasion them in the latter periods of the alteration of their texture; and that, in this respect, they are but a symptom in the greatest number of cases, and a symptom

wholly disconnected with any sort of compression. 2d. By supposing that the liver could exert upon the vena cava an analogous compression, in the place where this vein crosses its posterior part, it is evident that the anastomoses of which I have just spoken, would prevent the effect of this compression, at least in great measure.

By supposing that an obstacle was encountered in the vena cava superior, the same anastomoses would undoubtedly answer the same end; but as the azygos is inserted very near the auricle, as the course of the trunk of the vena cava superior is consequently very short, it is evident that it is especially to counteract the obstacles the inferior may experience, that these anastomoses have been established.

When the blood of this vein passes thus into the superior, it goes through certain branches in a direction opposite to that which is natural to them. For example, suppose that the anastomosis takes place in the renal, which most often happens; then the blood of the trunk of the vena cava enters by one extremity of this vein; that from the kidney comes by the opposite extremity, and both pass into the azygos. A similar motion evidently supposes the absence of valves in the renal, from the vena cava to the insertion of the azygos. Now the renal veins never in fact have these folds; the capsular, the adipose of the kidney, all the lumbar, are also destitute of them, as Haller has seen, and I have ascertained it to be uniformly so. This absence of valves at the places of the anastomoses of the azygos, is a remarkable phenomenon; it proves very well the use that I attribute to the communication of the two venæ cavæ by means of this.

ARTICLE SECOND.

ORGANIZATION OF THE VASCULAR SYSTEM WITH BLACK BLOOD.

I. *Texture peculiar to this organization.*

THIS organization is nearly the same for the whole system, in the common membrane that forms the great canal in which the black blood is contained; but it differs in the textures that are connected exteriorly with this membrane. In the heart the texture is fleshy; it is analogous to the texture of the divisions of the aorta, in the pulmonary artery; it has a peculiar character in the veins; it is this that will now particularly engage our attention.

Membrane peculiar to the veins.

In order to see this membrane, it is necessary to remove, 1st, the loose cellular texture that unites the veins to the neighbouring parts; 2d, the cellular layer of a peculiar nature that immediately covers them, and of which we have spoken in the article upon the cellular system. Then we distinguish in the great trunks, longitudinal fibres all parallel to each other, forming a very fine layer, often difficult to be seen at first view, but always having a real existence. When the veins are much dilated, these fibres being more separated, are less evident than in a state of contraction. These longitudinal fibres are seen more clearly in the trunk of the inferior vena cava than in that of the superior. In general it may be said, that they are also more marked in all the divisions of the first than in those of the second; dissection has convinced me of this. Undoubtedly this arises from the greater facility that the blood experiences in circulating in the second than in the first of these veins, in which it

mounts against its own weight; this is moreover a proof that man was designed to go erect.

I have uniformly made another remark, it is, that in the superficial veins these fibres are much more evident than in the deep-seated ones; the internal saphena is a remarkable example of this. It suffices to open it in its course, to see very distinctly its fibres through the common membrane, especially if it is a little contracted. By cutting the crural vein to compare it with this, it is easy to perceive the difference, which arises without doubt from this circumstance, that the neighbouring parts assist the circulation in the deep veins, whilst there is less of this assistance given to the superficial ones.

The branches have fibres in proportion greater than the trunks; hence the proportional excess of the thickness of their parietes, their greater resistance to the blood, their less frequent dilatation, &c.

At the place where any branch arises from a trunk, we observe that the fibres change their direction and go upon the branch, a circumstance that distinguishes them from arterial branches, whose fibres are not a continuation of those of the trunk.

Venous fibres oftentimes approach each other, are united, and give a greater thickness to the vein; this is frequently observed at the origin of the saphena. I have also seen this arrangement in the hypogastric vein; Boyer has likewise noticed it.

In general, the venous fibre, except in these places, is remarkable for its delicacy, for the little thickness that it consequently gives to the membrane that it forms. The peculiar membrane of the arteries infinitely exceeds that of the veins in this respect; it is this delicacy that favours to a great degree venous extensibility. Observe that the structure of each kind of vessels is adapted to their peculiar circulation. If the blood circulated in the veins with parietes like those of the arteries, its motion

would be continually disturbed. A thousand causes retard the venous blood; when its motion is languid, the capacity of the vessels is increased; now, the arterial textures not allowing of this dilatation, it is evident that the circulation would be interrupted. If then the agent of impulse, placed at the commencement of the arteries, requires a firm and unyielding texture, the slow motion of the blood in the veins, the frequent causes that retard its progress, demand a texture of an opposite character.

What is the nature of the venous fibre? Its appearance, its want of elasticity and brittleness, its great extensibility of texture, its softness, its colour, its direction, distinguish it completely from the arterial fibre. Is it muscular? it does not appear to be irritable, and it does not look like the muscular fibres. I believe that it is of a peculiar nature, essentially different from that of all the other textures, having its peculiar properties, life and organization; I do not think it capable of much motion. We have, however, but few data upon this point.

The venous fibre, though infinitely more extensible than the arterial, is also more resisting; it will support without breaking, very considerable weight. The experiments of Wintringam have proved this. In the superficial and inferior veins especially, this is very remarkable.

There is a great difference in individuals as it respects the venous fibres. In some they are very apparent; in others, they are hardly distinguishable upon the great trunks; but then they are always very evident in the branches, particularly in the superficial ones.

There are places in the venous apparatus where we cannot discover either external fibres, or external cellular texture; this is the case with the cerebral sinuses, which have the following arrangement. The jugular vein at its sinus, loses its peculiar texture, and keeps only the common membrane, which, entering the lateral sinus, lines it, and extends below into the inferior longitudinal sinus,

and above into the superior; in a word, into all the sinuses of the dura mater. Hence every sinus supposes, 1st, a separation of the layers of the dura mater; 2d, the common membrane of the black blood lining this separation. It is not then upon the dura mater that the blood circulates; it is upon the same membrane that it flows elsewhere; it is easy to establish this fact in the superior longitudinal sinus. This sinus is triangular when considered in relation to the separation of the layers of the dura mater; but in opening it, we see clearly, that the common membrane, by passing over its angles, makes it round; this is very evident. It is easy, also, in many other sinuses, to separate in certain places this membrane from the dura mater; but in the greatest number the adhesion is close, like the union of the arachnoides with the internal surface of the dura mater. This common membrane of the black blood is spread over the folds of the superior longitudinal sinus; it forms a singular net-work, which I shall describe in the cavernous sinuses.

From this general outline, it is evident that the coats of the dura mater supply in the sinuses the place of the venous fibres and their external dense cellular texture; the common membrane is always the same; but the texture that is added to it externally is different. At the place where each cerebral vein opens into a sinus, the common membrane of that sinus connects itself with it in its passage and lines it to its extremities. I know of no author who has thus considered the cerebral sinuses, as having the common membrane of the black blood extended into all the separations of the dura mater. How little soever we examine the internal surface of a sinus, it is easy to see that this surface differs as much from the texture of the dura mater, as it resembles the internal surface of the veins.

The cerebral veins, of which the sinuses are the terminations, are analogous to the arteries of that part in

the extreme tenuity of their parietes, a tenuity that appears to be owing to the absence of the cellular coat, and which is so great, that you might believe that there was only a common membrane.

There are no circular fibres in the veins.

Common Membrane of the Black Blood.

This membrane generally extended from the general capillary system to the pulmonary, is every where nearly of the same nature. It differs essentially from that of the red blood in a great number of respects.

1st. It admits of much greater distension; consequently it is less brittle. Tie a vein, and it will not break, unless the constriction be excessive; it is almost as pliable as the cellular coat. This pliability renders it much easier of dissection than the common membrane of the arteries. 2d. It appears to be much more delicate; we have a proof of this in the valves, which at first view are hardly visible from their extreme tenuity, when they are lying against the external surface of the vein. 3d. This common membrane is never ossified in old age, like that of the arteries; its organization seems to resist the deposition of phosphate of lime. When it does take place, it is an unnatural state; whereas the ossification of the common membrane of the red blood is almost a natural state in old age, as I have before observed. This difference between the two common membranes of the black and red blood, gives a distinctive character to the diseases of the heart. We never see ossification in the tricuspid valves, or in the semilunar valves of the pulmonary artery, whilst they are so frequent on the left side; this is the uniform result of observations made at the Charity; in the bodies of old people dissection has always shown me the same thing. So the pulmonary artery, though analogous to the aorta by its peculiar membrane, is never the seat of these ossifications, because

the common membrane differs essentially from its own. This single phenomenon, so striking in both these membranes, would incontestibly prove their organic differences, while it establishes the necessity of considering them in a general manner, whether, in the black blood, they line the veins, the pulmonary artery, and the right side of the heart, or in the red blood, they are spread upon the arteries, the left side of the heart, and the pulmonary veins.

Of the Valves of the Veins.

The common membrane of the black blood has numerous folds that are called valves. These folds are wanting in the pulmonary artery, except at its origin, where we find the semilunar valves; in the heart, the tricuspid valves are in part formed by this membrane; but the venous valves are wholly made by it; it is with them that we are particularly concerned.

The form of these valves is parabolical; their convex edge is attached, and most remote from the heart; their straight edge is loose, and nearest that organ. There is between them and the vein a space analogous to that of the semilunar valves of the aorta and the pulmonary artery. They have not, like these valves, a granulation upon their loose edge. On a level with the attached edge, the venous texture is firmer; there is a kind of hardening, which makes a prominent line of the same curved form as that edge. This hardening supports the valves, like the one corresponding to it in the semilunar valves. It appears to be of the same nature as the venous texture, the direction of whose fibres are changed to form it. When the common membrane arrives at this prominent line, it is folded to form the valve; so that it seems to be made of two layers, which are separated with difficulty, from its extreme tenuity.

The venous valves exist in the inferior vena cava, as in the superior. In the first, the divisions of the hypogastric, of the crural, tibial, internal and external saphena veins, &c. are full of them. The second presents many of them in the external jugular, in the azygos, in the facial veins, in the veins of the arms, &c. Many veins have no valves, as we see in the trunk of the inferior vena cava, in the emulgents, in the cerebral sinuses, &c.

The size of the valves is always in proportion to that of the trunks in which they are found; very distinct in the azygos, less so in the saphena, and still less so in the plantar veins. If we compare them with the caliber of the trunk they occupy, we shall see that sometimes they can entirely obliterate its cavity, and that at others they are too narrow to produce this effect. All authors have noticed this arrangement; they have thought that it depended upon primitive organization; but I am convinced that it arises wholly from the state of dilatation or contraction of the veins. In the first state, the valves being drawn and not dilating in proportion, become smaller compared to the caliber of the veins, whose cavity they cannot entirely obliterate when they fall down. In the second state, as they do not contract in proportion to the vessel, they become more lax and are capable of closing it completely. All that has been written by authors upon the size of the valves, depends then wholly upon the state of the veins at the moment of death. This is so true that they appear large if the animal dies of hemorrhage, and small if he dies of asphyxia. I have twice proved this fact.

From what has just been said, it is evident that the reflux of black blood takes place much easier and extends much further when the vein is dilated; and that consequently the first pulsation, the effect of this reflux, does not extend as far as the second, nor this as far as the third and so on. It is this that happens in the cases that

we have spoken of before. The reflux never extends to the capillary system, especially in parts at a distance from the heart, because there being many valves and each checking in a degree the blood, it soon stops by losing all the motion received from the heart.

The existence of valves is generally constant, but their situation and number are very variable. Sometimes they are very near each other, at others at a greater distance, in this respect there is a great variety. Generally in the small trunks they are nearer, and at a greater distance in the large ones.

They are rarely arranged three by three, most often in pairs, and sometimes they are insulated; this is the case especially in the small vessels, in those of the foot, of the hand, &c. We find in the works of Haller very minute descriptions of the general arrangement, form and position of the vascular folds of which we are treating.

These folds perform, as we shall see, an important part in the venous circulation; by them we are enabled in most operations, to dispense with tying the venous trunks, if they are not very considerable. In fact, without them, the blood poured by the collateral branches into the open vessel, would easily escape by a retrograde motion, and then we might fear the effusion of all that, which passes in the whole course of this vessel, whilst now none can escape except what flows between the opening and the first or second valve.

The valves constitute an essential difference between the veins and the arteries. Let me observe, that the want of them in these last vessels is a proof in addition to what has been already named, of the absence of vital contractility in their texture. In fact if they contracted like the heart to drive the blood, this fluid, tending as much to return towards the heart by the effect of this contraction, as to go to the extremities, there would be at intervals in the arterial tubes, valves to counteract this first motion:

now we only see them at the origin of the aorta; why? because it is only necessary in the arteries to resist the effect of the contractility of texture, which, exerting itself without a jerk, by a mere contraction, can return but very little blood to the heart. A single obstacle at the beginning of the arterial system, is sufficient then to prevent the derangement of the circulation, which might be the effect of the reflux caused during the systole by the contractility of texture of the arteries, a reflux which only takes place in certain cases; for ordinarily the return of the arteries upon themselves, is produced as I have said, by their containing less blood, which has been driven through them during the diastole. In order that this reflux might take place, it would be necessary that the effect of the contractility of texture should in the systole exceed what the arteries have lost of blood in the diastole.

Action of re-agents upon the Venous Texture.

This texture exposed to drying, becomes yellowish, remains pliable and can be bent in any direction; so that the dried venous bands, might in this respect, be applied to uses, to which the arterial could not in the same state.

This texture becomes putrid also more easily than the arterial, but less so than the others, particularly the muscular. To ascertain this, I have exposed at the same time, venous trunks and portions of intestines of fine muscular layers, to the contact of a moist air.

It resists maceration less than the arterial texture, but more than the others; water in which it has been macerated by itself is much less fetid than that in which an equal portion of muscular texture has been placed.

The horny hardening of the venous fibres is very evident when they are plunged into boiling water or the concentrated acids. They contract then more than half, at the same time they become more evident; in this way they can be studied better; I have used it often; their

contraction thickens the parietes of the vein. When they are hardened in this way, if they remain in boiling water or the acids, they become soft very soon in the second, more slowly in the first. Boiling acts upon them quicker than upon the arterial fibres; they can also be reduced by long ebullition to a pulpy state, to which we can never bring the arteries.

The caustic alkali seems to have a very remarkable action upon the veins. After remaining a short time in a solution of this alkali, they become diaphanous, diminish in size, do not entirely dissolve, it is true and become liquid, as in the acids, but evidently lose their elementary principles, give a remarkable precipitate, and always render the liquor less strong, by the new combinations which it forms.

II. *Parts common to the organization of the Vascular System with Black Blood.*

Blood Vessels.

The veins have in their texture little arteries and veins, which take very much the same course as in the arteries. They ramify at first in the cellular membrane, send small branches to the neighbouring parts, then penetrating the venous fibres, wind there in a thousand different directions and finally terminate about the common membrane, which when injected has appeared to me to receive more than in the arteries.

Cellular Texture.

The veins, like the arteries, have around them two kinds of cellular texture; one which is exterior and of the same kind as that which is found in the interstices of all the organs; it contains fat and serum, and serves only to connect the veins with the adjacent organs; the other dense and compact, forms for them a proper coat. No

author has yet distinguished the cellular system of this particular texture from that which is generally spread over the organs, though it differs from it so essentially in its filamentary texture, in its dryness, its uniform want of fat and serum, its remarkable power of resistance, &c. When we raise it, by tearing it with the fingers from the veins, it appears as if it was formed of an infinite number of little filaments interwoven with each other.

After having formed this external covering to the veins, this cellular texture of a peculiar nature analogous to the sub-arterial, sub-mucous, &c. passes between the longitudinal venous fibres, separates them, forms for them a kind of sheath, and terminates in the common membrane, which appears to contain it in its texture, and which owes perhaps in part to this circumstance, the great extensibility that it possesses.

I would observe that the presence of the cellular texture in the venous parietes is a distinctive and striking character that distinguishes them from those of the arteries, with which their texture has in other respects no kind of analogy.

Exhalants and Absorbents.

It appears that there is no exhalation upon the internal surface of the veins. This surface is always moist in the dead body, though the vessels are empty; but I attribute this phenomenon, as in the arteries, to a transudation that has taken place after death. If there was in fact a fluid exhaled, it would prevent the adhesions of the venous parietes, when during life the blood ceases to flow through them. Now every vein that is empty is obliterated into a sort of ligament, like the arteries in similar cases.

There is no more absorption upon the internal surface of the veins, than exhalation. To satisfy myself of this fact, I have tried upon the external and internal jugular veins, the same experiment before noticed, as having been

made upon the carotid artery; I obtained the same result and drew from it the same conclusion. I have been induced to make these experiments, from the opinion of many distinguished anatomists, who thought that the absorbents arose immediately from the veins and the arteries. It is possible that this is the case in the smaller branches, in the capillary system especially, as I shall say in the absorbent system; but I do not believe that any thing similar can be demonstrated in the trunks.

It appears then that the exhalants and absorbents of the venous parietes, like those of the arterial, are confined to the nutritive functions, and that they are consequently few. This remark is applicable not only to the veins, but to the whole of the vascular system with black blood.

Nerves.

1st. The veins differ essentially from the arteries by the few nerves of the ganglions that accompany them. Whilst these nerves form for most of the arteries a kind of covering, they are scarcely spread at all upon the veins. By laying bare the venæ cavæ, jugulars and azygos, it is easy to observe this. 2d. The side of the heart with black blood, receives as many nerves as that with red; this proves that they have no influence upon the contraction, as it is evidently weaker on the right side than the left; whereas if it was produced by the nerves it would be equal, as there is an equal distribution of them. 3d. The pulmonary artery has but very few nerves. I know not as yet the relation that exists between it and the pulmonary veins in this respect.

It appears from this general survey, that the system with red blood has many more nerves than that with black. In fact being nearly equal at the heart, and the difference being very sensible in this particular between the aortic arteries and the veins that go to the right auricle, although the pulmonary artery may have a few more than the cor-

responding veins, which I think very probable, yet the short course of these vessels would not prevent the disproportion from being very apparent.

ARTICLE THIRD.

PROPERTIES OF THE VASCULAR SYSTEM WITH BLACK BLOOD.

The veins are in general but little elastic, soft, and loose; they partake of the character of many of the animal textures, and are essentially distinguished in this respect from the arteries, which as we have seen are very elastic. We shall now treat of the vital properties and the properties of texture in these vessels.

I. *Properties of Texture. Extensibility.*

The veins have in regard to this property, an arrangement entirely opposite to that of the arteries, which are very extensible longitudinally, but very little so transversely.

The veins stretch but little in the first direction. When drawn out of a stump after amputation upon the dead body, they lengthen but little in proportion to what they dilate in varices, though here they experience an actual increase of size. Perhaps however this depends less upon the deficiency of extensibility of texture, than upon the circumstance that the folds are less evident than in the arteries, and of course the development is less. Whatever may be the cause, the fact is certain and uniform.

Few organs, on the other hand, exhibit a greater degree of extensibility transversely, than the veins. In the dead body, they can be enormously dilated, by injections of air, water, fatty substances, &c. In the living, we know the varicose dilatations, which arise in the great trunks, from the obstacles to the course of the blood in

the lungs. While the arteries do not appear very often more than to double their diameter without breaking their common and peculiar membrane, the veins treble, quadruple, and even quintuple their diameter without this rupture's taking place.

We have however numerous examples of this accident. Haller has related many in his great work. We see these ruptures take place during pregnancy in the veins of the lower extremities; there are examples of them also in the external veins of the head in violent headaches. We have seen the venæ cavæ, the jugulars, the subclavians suddenly break and produce death. Every one knows of the hemorrhages that arise from the rupture of the hemorrhoidal veins, &c. I think that the extreme tenuity of the parietes of the cerebral veins exposes them to being frequently torn by blows upon the head, wounds upon that part, &c. When there is an effusion in the tunica arachnoides, it can certainly come from no other source than the venous trunks, which being surrounded by a fold of the arachnoides, pass through this cavity to go to the cerebral sinuses. Now we know that this case is very common, and that it even takes place at the same time with that, in which the dura mater being detached from the cranium, is found separated by an effusion. Is not apoplexy a sudden rupture of the venous extremities? I have already observed that we have no data upon this point. All these cases are very different from arterial aneurism; they often take place when the dilatation is infinitely less than in many instances where the veins remain whole. Very commonly this does not happen. The whole of the vein, with the cellular tunic containing it, bursts. The arterial rupture in true aneurisms, is on the contrary uniform; when the dilatation is carried to a certain point it always happens. The two arterial coats break easily, the cellular remains whole. I do not believe that there is a solitary instance of a great aneurism, without rupture. Why?

because the arterial extensibility can only yield to a certain point. The ruptures take place then from a want of this property; they are disconnected with this cause in the veins. We do not know yet how they are produced. In a great number of cases certainly, there is an affection of the venous texture; this is undoubtedly the case in hemorrhoids, &c. Let us be content to point out the differences between arterial and venous ruptures, and wait till further observation shall discover to us all their causes.

If we bear in mind, that the arterial fibres are very numerous and all circular, that the venous, on the contrary, are on the one hand longitudinal where they exist, and on the other that they are very thinly scattered on their vessels, we shall then see why the first resist much longer a distension in the direction of their diameter than of their axis, and why the opposite phenomenon is observed in the second, though much less decided.

Contractility.

This corresponds with the extensibility. Slight in the longitudinal direction, much greater in the transverse. 1st. It produces the contraction upon themselves, of the parietes of the umbilical vein, of any trunk that is tied, &c. 2d. It produces in a trunk that is pricked, the sudden evacuation of the blood contained between the two ligatures by the return of the parietes upon themselves. 3d. It manifests a decided influence on the flow of blood in venesection. 4th. The numberless varieties of caliber that the veins exhibit after death, according to the quantity of blood they contain, are the result of their extensibility and contractility of texture. 5th. During life, the superficial veins appear very various; dilated in summer, contracted in winter, expanded in the warm bath, as we see the saphenas, especially in pediluvium, lessened in the cold bath, prominent by a long continued perpendicular position, flattened by a horizontal one, &c.

they present to him who observes them, at different times, numerous varieties. I very much doubt whether those who have calculated so much the capacity of the vessels, the velocity of the blood, &c. would have undertaken their labours, if they had opened many bodies, or made many experiments upon living animals; now all the varieties depend upon the extensibility and contractility of texture.

II. *Vital Properties.*

Properties of Animal Life.

Have the veins sensibility? The following is the result of my experiments upon the subject. 1st. Irritated externally by any mechanical instrument, pain is not produced, as Haller has seen; 2d, a ligature put upon them gives no pain, whether it is done upon living animals, or in certain surgical operations, in great amputations, for example, in which it is recommended to tie the vein as well as the artery. 3d. Irritated internally, they exhibit the same phenomenon. I have many times pushed a stilet very far into one of these vessels, without making the animal cry out. I would observe also, that this is a good method of examining the sensibility of the heart, without producing in the chest a disturbance, that would increase, diminish, or alter this property in any manner, by the general derangement that it would occasion in the economy. I force then a long stilet into the right external jugular vein, opened as it is in the operation for bleeding. This stilet goes to the heart, without any accident, by straightening out the venous angles. The animal oftentimes gives no sign of pain; sometimes, however, he does; the motion of the pulse is always accelerated. We might easily reach in a man, without accident, with a stilet, the right side of the heart, by introducing it into the right external jugular vein. Why, in certain as-

phyxias, in syncopes which resist all other stimulants, &c. might we not employ this method to re-animate the action of the heart? 4th. When we inject a foreign fluid into the veins, however irritating it may be, the animals rarely show any sign of pain. Urine, bile, wine, the narcotics, &c. are transfused with impunity in this respect. 5th. On the contrary, when a bubble of air enters them, the animal cries out, is agitated, and struggles before dying; is this owing to the contact of the fluid upon the common membrane? I believe not; for usually there is an interval between the cries and the injection of the air. It is possible that the pain happens at the instant when the air strikes the brain, after having passed through the lungs, a passage which is constant, as I have observed elsewhere.

There is evidently no animal contractility in the veins. The same experiments that demonstrate its absence in the arteries, prove it also as it respects the veins. I have made them at the same time upon both kinds of vessels. I refer, then, upon this subject to the preceding system.

Properties of Organic Life. Sensible Contractility.

This property does not appear to be an attribute of the veins. Haller, by irritating them in different ways, perceived no sensible motion in them. I have usually made the same observation, whether I employed internal or external irritation.

It has appeared to me, however, in two or three cases, that a manifest contraction took place. As the venous fibres are only longitudinal, and as they are very few, it is evident that in admitting that they are muscular, it would be very difficult to observe the effect of irritants applied to them, though it might be real. The question is not, then, fully settled, though I incline much more to the belief that there is no venous irritability. As the

venæ cavæ have evident fleshy fibres at their origin, it is evident that they possess at that place the contractility of which we are treating.

A proof of the great obscurity of the sensible organic contractility in the veins, is, that it is never increased in disease. All the organs, in which this property exists, are remarkable for its frequent increase, which constitutes in the heart the quickness and the force of the pulse, in the stomach vomiting, in the intestines diarrhœa, in the bladder incontinence of urine, especially in children, &c. Now the veins never exhibit a derangement, which, corresponding to these, would make us believe in the existence of a power of which this derangement is the excess, if I may so say.

Observe, that this observation is also applicable to the arteries; never in a determinate portion of the arterial system, do we see this local disturbance, this insulated derangement, which certain portions of the intestinal canal sometimes exhibit. The irregularity of the motion of the blood is always general, because it arises from a single cause, viz. the irregular impulse of the heart.

Observe, that this way of discovering the presence or absence of this or that vital force in a part, by the affections which increase that force there, deserves an important consideration in the examination of these forces. Authors have not employed this method of discovering them, of pronouncing consequently upon their presence or absence in the organs.

Of the Venous Pulse.

The pulsation that the veins have under certain circumstances, must not be taken for an effect of the venous irritability. It is an effect of the reflux of the blood, which not being able to go through the lungs, stagnates in the pulmonary arteries and in the right side of the heart: so that when this contracts, as the blood finds an

obstacle in the ordinary course, it flows back whence it came, as when the aliments are unable to pass down, they take the other direction. This reflux takes place, to a certain distance, notwithstanding the valves; it is often very evident in the jugular vein, when animals, submitted to experiments, breathe laboriously; then it is discontinued; it takes place three or four times, then ceases, and returns irregularly; it is observed also in the last moments of life, when the lungs are embarrassed.

The vein is then sensibly dilated; then it contracts. But if you apply the finger above, you do not experience a sensation analogous to that of the pulse; you will perceive only a wave of blood which flows back. The reason of it is plain; 1st, there is no locomotion; 2d, as the venous parietes are loose, they could not strike the finger sufficiently strong, if there was a similar change of place. Observe, that it is less the blood than the artery itself which by its firm texture gives the sensation of the pulse; if it could straighten itself when empty, as it does when it is full, it would produce nearly the same sensation; this is a remark that should be added to what I have said upon the pulse in the preceding system.

The contraction of the veins in the motion of the reflux, of which we are treating, is only the contractility of texture. When the heart ceases to propel the blood in its cavity, it contracts, after having been dilated; it is nearly the same in the dead body, in which we fix a syringe in the veins; when they are very full of water, if we draw back the piston a little, immediately the fluid returning, the vein contracts; it is as when it contracts from a puncture that evacuates the blood; this does not imply any irritability.

I believe that sometimes this reflux may depend upon an irregular motion of the heart, which contracts in an

opposite direction to the ordinary one, though there is no obstacle in the lungs. What induces me to think so, is, that frequently in experiments, at the moment the animal begins to suffer much, the reflux takes place before the lungs have had time to be disturbed. A very remarkable thing in experiments is the quickness with which pain disturbs the motion of the heart, accelerates it, renders it irregular, &c. We can always at will hasten respiration, by making the animal suffer; now the acceleration of the pulse is always prior to that of respiration, which appears to be determined by it. I am persuaded that if the diseases of the heart were as frequent on the right side as the left, they would often produce this reflux and this pulsation of the veins.

The limits of the reflux of the venous blood vary. Haller has observed it as far as the iliacs. In general, it rarely goes beyond the great trunks, on account of the valves. I have demonstrated in my Researches upon Death, that the colour of those who die of asphyxia, of those who are drowned, &c. does not depend on this, because it cannot evidently extend to the capillary system, which receives the black blood that colours it, from the arteries that then circulate that kind of blood.

The reflux of the black blood in the veins, produced in the preceding cases, either by an obstruction in the lungs, or by a sudden derangement in the action of the heart, takes place in a natural state, though in an infinitely less degree. In fact, when the right auricle contracts, all the blood does not pass into the corresponding ventricle; the veins being open, a portion flows back into them. It is difficult to determine the extent of this natural reflux, of which all authors have spoken. When the thorax is opened, we observe it distinctly; we might then ascertain its extent; but in this case, respiration not being performed as usual, it is evident that we cannot judge by it of what ordinarily takes place.

Insensible Contractility.

This property, which, like the preceding, is inseparable from the organic sensibility, exists in the veins as in the other parts; it presides only over nutrition; it appears more evident than in the arteries; at least the diseases which particularly increase it are more frequent in the veins. The texture of these vessels is often inflamed. 1st. Bell relates cases of it, the effect of external violence. 2d. Every one is acquainted with the inflammation of the hemorrhoids. 3d. The cicatrization of venous wounds after bleeding is a product of inflammation. Without doubt this cicatrization is promoted by the want of impulse, to which the arteries are subjected; but certainly these last would not in like circumstances heal so fast, if they did at all. When an artery has been tied, it is necessary that its parietes, inflamed by the action of the thread, most often cut by it, and brought into contact, should form adhesions, that the cure may be complete, and the ligature come off without danger. Now, nothing is more difficult and slower than their adhesion, from the difficulty with which the arterial texture inflames. Hence the frequency of hemorrhage after the operation for aneurism and other great operations. The blood often bursts out at the end of twenty, thirty, or forty days; the surgeon should always be upon his guard when he has tied these great trunks, from the want of disposition in the arterial texture to inflame. Frequently when the artery is obliterated, it is not by inflammation. Whilst the ligature stops the blood, the portion of artery comprised between it and the first collateral branch, closes gradually by the contractility of texture, and forms a kind of ligament, which arrests the blood after the thread has fallen off. I do not know but that these cases are more numerous than those of inflammation. Now the veins always adhere soon when they are tied; their

wounds cicatrize immediately. In great wounds it is almost always useless to tie them at the first moment, on account of the valves, as I have said above, and afterwards, because the cut ends contract, and soon inflame and adhere. If there are venous hemorrhages, it is at the time of the injury, and not as long after as in the arteries.

Every thing proves, then, that the vital activity is much greater in the venous than in the arterial system, in respect to the tonic powers. The absence of the cellular texture in the second and its presence in the first, may have an influence upon this phenomenon.

Observations on the motion of the Black Blood in the Veins.

From what has just been said, it appears, that the blood is beyond the influence of the heart when it arrives in the veins. It is evident, then, that the veins can have no pulse. 1st. This phenomenon depends upon a single impulse, suddenly received by the contraction of the left ventricle; now, the blood is poured from all parts by the capillary system into the veins, this agent of impulse is wanting; the cause of the pulse does not exist in the veins. 2d. The necessary conditions for its production in the texture of the vessels in which it takes place, are elasticity and resistance, which are also wanting in the veins. They are only susceptible, then, either of a pulsation which occasions the reflux of the blood in the derangement of the lungs, or in the irregular motions of the heart, or of an undulation of which they are the seat, when arterial blood accidentally circulates in them; now, in either, the heart is the principle of motion, and it could not exist without it.

This is what takes place in the venous motion. The capillary system, by its insensible contractility, pours continually into the venous system a certain quantity of blood. This fluid, added to what is already there, com-

municates a general motion to it. Now, as the whole venous system is constantly full, it is necessary that while the fluid enters at one side it should go out at the other; if not, the venous parietes would dilate; but, as they have a resistance by which they can act to a certain point upon the blood, this fluid not being able to dilate the veins, flows towards the heart.

The impulse given by the insensible contraction of the capillary system, is too weak, however, to extend instantaneously from one extremity of the veins to the other, especially where the blood rises against its weight. As this fluid enters these vessels, the weight of that which is before it not being overcome, it would produce a general dilatation, and the blood would not reach the heart; but the valves counteract this, by supporting at short distances the column of blood. Weakness of the venous parietes and the existence of valves are necessarily connected. If the veins were as strong as the arteries, unable to dilate when the blood enters them, they would necessarily transmit the surplus to the heart, if they were destitute of valves; but on the other hand, their circulation would be every instant embarrassed.

It appears that it is not only the insensible contraction of the capillary system which propels the blood in the veins; but that the ramifications of these vessels have a kind of absorbent power, by which they draw blood into this system. Now the insensible motion produced by this power tends evidently from the ramifications towards the trunks, as in the lymphatics; then, when, on the one hand, the blood is propelled in the veins, and, on the other, as it were, attracted by them, it is evident that the primitive source of motion that it obeys, is in the capillary system.

This impulse communicated to the blood, exceeds but very little the resistance which this fluid experiences in its motion; so that the least resistance deranges this motion. Hence, as we have seen, the necessity of anasto-

moses. Hence also the necessity of other assistance to aid this motion, such as, 1st, the muscular action, the influence of which we cannot doubt, when we see the flow of blood in venesection accelerated by the motion of the muscles of the fore-arm, the palpitations of the heart, produced by the blood that flows there after a rapid circulation; when we observe that varices are as rare in the veins situated among the muscles, as they are common in the sub-cutaneous ones, &c.; 2d, the pulsation of those arteries which are in many places joined to the veins, and which communicate to them a kind of motion; 3d, the motion of certain parts, like that of the brain, which continually rising and falling, accelerates the circulation of the blood of the sinuses in an evident manner; so also the constant locomotion of the gastric viscera, propels it in the veins of the abdomen, and that of the pectoral viscera, in those of the thorax. It is so true that the veins derive assistance to their circulation from external motions, that if a limb is a long time immoveably fixed when fractured, these vessels often dilate. 4th. External frictions, if they are not so violent as to embarrass the venous circulation, evidently facilitate it; this is one of the advantages of dry frictions. 5th. A slight compress, not sufficient to check the venous blood, often promotes its circulation, when the external organs are weakened. We know, since the time of Theden and Desault, the advantage of tight bandages, for varicose ulcers, even for varices, &c.

Since the principle of the motion of the venous blood is generally spread throughout the whole general capillary system, instead of being concentrated, like that of the arteries, in a single organ, it is evident, that this motion cannot be uniform, that it must vary according to the state of the capillary system in the different parts; that it can be more rapid in some veins, and slower in others. This is in fact what we see, especially externally where the

veins are more or less swelled, according as the blood circulates there more or less rapidly. In the arteries on the contrary, the motion is every where the same; it is a general and sudden shock, an impulse, which, every where felt at the same time, is necessarily every where uniform; so you never see some arteries more full, others more empty, as it happens in the veins.

There are numerous researches to be made on the motion of the blood in the veins. Notwithstanding all that authors have written upon this question, there is an obscurity in it in which we perceive but few rays of light. These difficulties arise from this, that we do not know precisely what is the kind and form of motion communicated to the blood in the capillary system, what is the influence of the vascular parietes upon this fluid, &c. &c. Our knowledge upon this point is reduced to certain views which I have just presented, and which are particularly relative to the parallel between the motion of the blood in the veins and the arteries. I believe that this parallel carried further at some future day, will throw much light upon the venous circulation; in fact, as the first motion is much more easily understood than the second, we must proceed from what is known to what is unknown, and place in opposition what we are acquainted with in one, with that which we seek to know in the other. This is the summary of this parallel, though imperfect; 1st, General pulsation in the arteries, absence of this general pulsation in the veins. 2d. Rapidity of the course of the blood in the arteries; slowness of the same course in the veins. 3d. Greater capacity and thinner parietes in the veins; less capacity and greater thickness in the parietes of the arteries. 4th. Necessity for accessory assistance for the venous circulation; the inutility of this assistance for the arterial circulation. 5th. The blood flowing per saltem, from the second, the uniform flow from the first. 6th. The susceptibility of the blood in the veins, to be in-

fluenced by its gravity and other accessory causes; there is some of this influence in the arterial motion. The following are the phenomena, which, from what we have just said, evidently depend upon the existence of an agent of impulse at the origin of the arteries, and of the absence of this agent at that of the veins.

1st. Constant uniformity of the motion in the arteries; variety of motion in every part of the venous system; 2d, dilatation and contraction generally the same in all the arteries of dead bodies; extreme variety in this respect in the veins of the different parts; these are the other phenomena which arise from the unity of impulse in the first, and from the varieties of the principle of the motion of the blood in the second, &c.

Some authors have insisted much, in explaining the causes of the difference of the arterial and venous motion, upon this, that in the arteries the blood is propelled in decreasing vessels, to the capillary system that resists; in the veins on the contrary it flows in vessels always increasing till it arrives at the right auricle, which offers no resistance. But the black abdominal blood is also carried without the agent of impulse, in a series of decreasing tubes to the capillary system of the liver, and yet the motion is analogous to that of the veins.

Sympathies of the Veins.

The sympathies of the veins are very obscure, like those of the arteries. As the textures of these two kinds of vessels are rarely affected, as inflammation and the different kinds of tumours do not frequently exist in them, and as they are hardly ever the seat of pain, we know but little of the influence they exert upon the other textures. However when we transfuse substances into the vessels, we have often seen acrid and irritating ones upon being introduced into the veins, produce sudden convulsions in different muscles.

As to the influence that the other organs when affected, exert upon the veins, we know also but very little. As they are every where disseminated, like the arteries and the nerves, it is difficult often to know if it is the vein itself or the organ that it forms, which is the seat of the sympathetic phenomenon.

ARTICLE FOURTH.

DEVELOPMENT OF THE VASCULAR SYSTEM WITH BLACK BLOOD.

I. *State of this System in the Fœtus.*

The veins have in the fœtus an arrangement inverse of that of the arteries; they are in proportion much less developed. It is not in the great trunks, as in the venæ cavæ, subclavians, iliacs, &c. that we should compare these vessels, because the reflux of the blood at the moment of death often dilates these trunks, so as to make us believe that they are much larger than they really are in a natural state. It is in the branches and the ramifications that we should make the comparison; now it is easy to see there, that the veins nearly equal the arteries, but are not superior to them, as is uniformly the case in the adult.

However, the side of the heart with black blood, and the pulmonary artery which make a part of the system with the veins, are proportionably larger than these. This arises not only from their receiving and transmitting the blood of these vessels, but also that of the umbilical vein. It is to this last circumstance that must be attributed also an anatomical fact always existing in the fœtus, viz. that the very short trunk of the vena cava, which is extended from the liver to the heart, is found in proportion much greater

than the trunk of the superior vena cava, which is not the case in after life.

The less development of the venous system, compared with that of the arteries, appears to arise in the fœtus from this, that much substance being employed for nutrition which is very rapid in the early periods, less returns by the veins. This phenomenon however is not peculiar to the black blood. We shall see that the excretories transmit less fluids by the glands, and that the exhalants pour out less upon their respective surfaces. Much blood enters the general capillary system of the fœtus; hence why the arteries are very large. There remains in the organs, much of the substances that it contains, to nourish them; but little goes out of the general capillary system for secretions, and exhalations; little returns by the veins.

The more the fœtus advances in age, the more of this blood is carried in the veins. In the early periods, almost all remains in the organs to form them. Towards the period of birth, these things approximate to what they will be in the adult.

In this general phenomenon of the venous system in the fœtus, the proportions are always preserved between the veins of the different parts, according to the increase of them. It is thus that most of the superior parts, the brain in particular, being in the fœtus the seat of a more active nutrition than the inferior, the veins there are also more developed.

We can hardly distinguish fibres at this age in the venous parietes, though they no doubt exist. I have only remarked, that they then contain much fewer small vessels in proportion than the arteries, whose trunks are covered with them, as it is easy to see upon the aorta.

Though less dilated than afterwards, the veins appear to be as strongly organized; their parietes are very resisting; they dilate less easily; this continues during the whole of youth. It is to this that I attribute the absence

of varices at that age. As on the one hand less blood circulates in the veins, and on the other they appear to be in proportion more resisting, it is evident that they must yield less.

II. *State of this System during growth and afterwards.*

A remarkable revolution takes place at birth, as we have seen, in the system of black blood. The right auricle and ventricle receive the whole of the blood, of which a part until then went immediately to the right side by the foramen ovale. This difference has not much influence upon the size of the right auricle and ventricle; differences only in their form take place, which I shall point out in the Descriptive Anatomy.

During the first years of life, the veins have a real inferiority as it respects the arteries. This inferiority continues during the whole time of growth; of this you may be satisfied by examining the external veins; they are never as evident, or as much developed in children as in an adult. Compare the arm of a man with that of a child, and the difference will be perceptible.

The proportion of the cerebral veins over the others, is gradually lost as we advance in age, because the brain does not continue to predominate so much in its nutrition.

At the period of puberty, and towards the end of growth in height, the veins partake of this general plethora, which seems to manifest itself, and which is, as we have seen, the source of many diseases.

When the growth in length and thickness is completed, the veins begin to have a larger diameter; they become more prominent externally; it appears that more blood constantly passes through them. Make the muscles of an adult man contract strongly, and you will see all the veins considerably swelled. The same experiment will not produce a proportional effect upon a young man; ligatures applied show the same difference.

III. *State of this System in Old Age.*

In the last years of life the veins become much developed compared to what they are in youth; we can say that in this respect, the two extreme ages exhibit an inverse arrangement. In considering the external appearance in the two ages, we may be convinced by the examination of the superficial veins, of the truth of this assertion.

Let us not think, however, that this greater development supposes an addition of substance in the venous parietes, as for example, the increased size of the bones depends upon the super-abundance of the phosphate of lime. It is a simple dilatation of these parietes, which are weakened, and become more slender, instead of increasing. This dilatation is owing to the loss of their elasticity and to the greater quantity of blood they carry. In fact the motion of decomposition evidently predominates in old age over that of composition. More substance is taken from the organs than is added to them, at this period. I know not but that the bones receive a greater quantity of the substance that nourishes them. In all the other organs, an opposite phenomenon is evident; hence their horny hardening, their withering, if I may use the term. Now, as the system with black blood is that in which is poured all the residue of the decomposition of the organs, it is not astonishing that it should be dilated in old age; so the system with red blood, which carries the materials of their composition, predominates in the first year of life.

The superabundance of black blood in old age however, is to a certain degree deceptive; it depends in part upon the slowness of the circulation in the veins, in which the blood, moved with difficulty on account of the weakness of the capillary system, tends to stagnate, and dilate them, as I have said before; so that though there would be less

black blood returning from the organs, there would be more in the veins, than in the adult; the velocity of the circulation then would be much less. There takes place in the whole system, what exists in a varix, for example, in which the blood accumulates because its velocity is diminished. It is not necessary then to believe, that the superabundance of the black blood in old age, supposes a plethora like that of the red blood in infancy, in which, on the one hand, the arteries contain more fluid, and on the other they propel it with greater velocity. We know from this that the dilatation of the veins in old age is a further proof of the principles established above; viz. that the capacity of the veins is always in an inverse ratio to the velocity of the fluids that go through them. It admits of but an inaccurate comparison, though it may give an idea of what passes in the venous system; a river which is very broad above a bridge, flows slowly; but its bed being much contracted under the arches, its velocity is much increased; so that the equilibrium may be established. So in the veins, there is little velocity and much capacity in old age, and much velocity and but little capacity in infancy.

Anatomists know very well the difference of the arteries and the veins at the two extreme ages of life; they choose old subjects to study the veins; on the contrary, these subjects are wholly improper for arterial injections, which succeed so well, and sometimes too well, in infants, in whom every thing appears to become vascular, and in whom the examination of the veins would be very difficult, and even impossible.

The veins of the inferior parts are generally more dilated in old age than those of the superior; this arises from the habitual weight of the column of blood, which constantly acting, produces finally a real effect; for, as we have said, the venous circulation is much influenced by mechanical causes, owing to the want of power in the

cause that circulates it; hence why varices are infinitely more frequent in the inferior than the superior parts, in which they are hardly ever found.

In women who have had many children, we see this dilatation of the veins of the inferior parts in a very evident manner; very often there are varices in them. Observe that this disease seems to be the companion of old age more particularly than that of every other age. On the contrary, we rarely see aneurisms in old people. The rupture of the veins has been almost constantly observed at this or the adult age. I hardly know an example of it in infancy.

The pulmonary artery does not dilate in old age in proportion to the veins; because, removed from the action of foreign bodies, and provided at its origin with an agent of impulse formed of a firm and resisting texture, it has not been in the habit of yielding like them.

IV. *Accidental development of the Veins.*

The veins are accidentally developed in two ways. 1st. In cancerous tumours, in fungi, &c. in which more red blood enters, they acquire a size in proportion to that of the arteries; now, as they are superficial, we see more easily their increase than that of the arteries; this increase, which has been taken for a characteristic of cancers and other analogous tumours, is only a consequence of the increase of nutrition. The motion of the blood is as rapid there as in the other veins; there is no obstruction to it. 2d. There are cases on the other hand, in which the veins dilate, because the blood cannot easily circulate in them, and because the velocity of its course is diminished. For example, the whole venous system of the abdominal parietes is often increased in ascites; it is not because there is more blood circulated; there is less than in the ordinary state; but it is because the venous parietes having in part lost their elasticity, like the neigh-

bouring parts, the circulation becomes slower; now the slower it is, the more the blood accumulates and the more the venous parietes are dilated. It is then a kind of general varix in a division of the veins. There is not more blood brought by the arteries, as in the preceding case ; the same thing in part happens in old age.

ARTICLE FIFTH.

REMARKS UPON THE PULMONARY ARTERY AND VEINS.

Though in the exposition of the two systems of black and red blood, I have considered the pulmonary artery as making a part with the veins, and the pulmonary veins as a continuation of the arteries, yet their nature is wholly different. There are in truth but two general membranes, forming the two great tubes in which are contained the two kinds of blood, which are every where of the same nature, from the capillary system to the pulmonary. The textures added to the exterior of these two common membranes are essentially different. Thus the texture of the pulmonary artery, though added to the membrane with black blood, is, in point of thickness nearly of the same nature as that of the aorta and its divisions. So the texture of the pulmonary veins, though united to the membrane with red blood, is the same as that of the other veins.

This uniformity in texture supposes an uniformity in the functions, and this is really the case. The mechanical laws of the circulation of black blood are the same in the pulmonary artery as those of the red blood in the aorta. So the laws of the general venous circulation are the same with those of the pulmonary veins; inspection proves this ; and, moreover, it must be so, since the re-

lation of the heart to the two kinds of vessels, the veins and the arteries, is the same.

Each system of blood, then, has its two modes of circulation. Sudden motion, generally communicated, and not the progressive undulation of the fluid; a pulsation by a real locomotion, a general straightening of all the divisions of the same trunk at each impulse of the heart; these are the general mechanical characters of the artery with red blood, as well as that with black. Absence of pulsation, slowness in the course of the blood, want of straightening, &c.; these are the general attributes of the veins of each kind of blood.

There are no doubt general modifications that arise from local causes. Thus, on account of the short course of the pulmonary veins, the weight has scarcely any influence upon the blood; they never become varicose; the motion of the fluid is more rapid in them, since they have less time to lose that which is communicated to the blood in the pulmonary capillary system, &c.; thus the artery of the same name, whose branches are less tortuous, does not seem to me to have pulsations as evident as those of the aorta, &c. But these general phenomena are always the same; they are but different modifications.

This is why the general arrangement is nearly the same in the veins and in the arteries, whether they circulate red blood or black. Thus, for example, each of the two arteries go off from a ventricle by a single orifice, necessary for the unity of the impulse of the blood, for the uniformity of its course in the divisions of its great vessels, and for the simultaneous pulsations in all the divisions. On the contrary, the veins pour into the heart the red and black blood by many separate orifices; this is of no consequence, since, as we have seen, the motion of this fluid in the veins is not uniform, but may be accelerated or retarded in a part, by the influences it receives:

thus, it may pass with velocity through the opening of the vena cava superior, and slowly through that of the vena cava inferior, &c.

From the preceding considerations, it seems, that if we have no regard but to the mechanism of circulation, that it is almost of no consequence whether we consider with the ancients the small and great circulations by studying first the course of the blood in the artery and the pulmonary veins, then in the aorta and the general venous system; or of studying, as we have done, the course of the blood, first in the pulmonary veins and the aorta, then in the general veins and the pulmonary artery. But if we consider this great function in the important relations of nutrition, secretions, exhalations, for which they furnish the materials, of the general stimulus it carries to all parts, and which is indispensable to the support of life, of the introduction of foreign fluids in the body of the animal, and of the change of these fluids into its own substance; then I think it must be described as I have done it.

ARTICLE SIXTH.

ABDOMINAL VASCULAR SYSTEM WITH BLACK BLOOD.

Situation, Forms, General Arrangement, Anastomoses, &c.

There is in the abdomen a system of black blood wholly independent of the preceding, arranged precisely like it, with the difference, that its course is shorter, and that it has no agent of impulse. This system, usually known by the name of Vena Porta, is found in most animals.

It arises from that part of the general capillary system which belongs to the intestines, the stomach, the omen-

tum, the spleen, the pancreas, &c. and generally to all the abdominal viscera connected with digestion. This origin is remarkable. The viscera in the abdomen, foreign to the phenomena of digestion, are also foreign to the origin of this system. The kidnies and their dependancies, as the glandulæ renales, the ureters, the bladder, the urethra, &c. the genital organs, the diaphragm, &c. the abdominal parietes themselves, &c. &c. pour their black blood into the preceding system. Why are the digestive viscera, in their whole extent, different from the others, in the destination of their black blood? To answer this question, we must know the uses of the system of which we are treating; now, of these we are ignorant.

Thus rising from the whole gastric apparatus, this system forms into two or three trunks, which soon unite into a single one, which occupies the superior and right part of the abdomen below the liver.

This common trunk soon divides again into many branches, which spread in the liver into an infinity of ramifications, and are spent upon the texture of that organ.

This system, then, presents the same general arrangement as the preceding; it is composed of two trees united by their lopped summits, that intermix with each other. Place an agent of impulse at these summits, the arrangement will be the same as in the two preceding. The blood is moved from one capillary system to another. Divided at first into small streams, it is formed into masses constantly increasing to a certain point, then it is divided again, and is carried in streams not larger than the first.

In the abdominal portion, the ramifications, the small branches, the branches and the trunks are arranged very nearly as in the general venous system. The ramifications are found in the organs, the small branches in their interstices, most of the branches are situated in the layers

of the peritoneum, there accompanying the arteries, and the trunks wind along the subjacent cellular texture. As to the hepatic portion, contained wholly in the liver, it is divided there nearly like the preceding.

The anastomoses present the following arrangement in the system of which we are treating. 1st. Its hepatic portion appears to want them; all the branches, smaller branches, and ramifications, go separately. As the circulation is not subject in the liver to increase or diminution, the solid texture of this organ protecting the vessels, the blood has no occasion for the means by which it can deviate from one place to another. Thus the great divisions of the pulmonary artery and veins, which go immediately into the lungs where they are wholly distributed, do not communicate with each other. Thus the branches of all the arteries and of all the veins contained in the interior of a viscus, as in the kidney, the spleen, &c. are most commonly without communication. 2d. As to the abdominal tree, its anastomoses are very frequent in the smaller branches. We see all along the small intestines arches exactly like those of the mesenteric arteries; less frequent in the great intestines, they are, however, very evident in them, as upon the stomach; in the branches and the trunks they do not exist.

The anastomoses in the system of black abdominal blood are necessary there from the frequent delays that this fluid may experience. For observe, that the circulation is performed for the abdominal portion according to the same laws as in the other veins, and that consequently that the force that can circulate the blood there, can yield to the least effort. Now in the different motions of the small intestines, often too great a fold, the pressure of these organs filled with aliments upon the veins, when we are lying on the back or the side, and which pressure the veins support only by their resistance, and a thousand other causes, impede the course of the

blood in one branch, and force it to flow by anastomoses into others. Observe also, that an obstacle which is of no consequence to the red blood, on account of the very strong impetus that is given to it, is very important to the two circulations of black blood, which receive but a feeble impulse.

The influence of gravity is evident in the blood of this system, as in that of the preceding. Thus you see the hemorrhoidal veins, more exposed than all the others to this influence by their position, become much more frequently varicose; and it is even rare to find dilatations in the superior mesenteric veins, splenic, gastro-epiploic, &c. &c. whilst there is no part in which they exist more often than in the hemorrhoidal. Thus we have seen the preceding system dilated rarely above, but very frequently below.

The system with black abdominal blood communicates but very little with the general system; if there are anastomoses, it is only in the last divisions; do these anastomoses exist? I believe we may consider these two systems as independent of each other.

Organization, Properties, &c.

Many authors, Haller in particular, considering that the system of which we are treating is destitute of an agent of impulse, have admitted in them a force of structure superior to that of the other veins; but after examining it attentively, I am convinced that it is precisely the same. The cellular covering, of a peculiar nature, which surrounds it, and which is analogous to that of the other vessels, is only a little more evident; this makes these veins at first appear thicker; but by raising this covering we see that the internal membrane is of the same nature, only perhaps a little less extensible. We do not discover the venous longitudinal fibres so well as in the preceding system; I doubt even if they exist

in the trunks, in which we should be able to see them better.

The two portions of this system, the hepatic and abdominal, appear to be completely uniform in their structure. Only the first is every where accompanied by a kind of membrane, which appears to be cellular, but whose nature is not yet well known, and which is called the capsule of Glisson. This capsule, intimately connected with the substance of the liver, adheres more loosely to the veins ; so that when they are empty, there is often a space between them and it; it is this that makes them fold up when we cut the liver in slices. I think that we are entirely ignorant of the object of this anatomical arrangement.

The analogy between the systems with black blood, the abdominal and general, supposes them the same in properties, sympathies, affections, &c. I have often irritated the mesenteric veins, upon which it is extremely easy to act, by drawing through a small wound of the abdomen a portion of the intestinal canal; the results have always been the same as in the preceding system. Only when we inject air, the animal does not struggle, does not appear to suffer, and the experiment is not fatal ; this proves still more, that it is not by its contact upon the veins or the heart, that the air is injurious, but by its action on the brain.

The common membrane of the system of which we are treating, is distinguished from that of the preceding, in this, that it is wholly destitute of valves. This appears to be owing to two causes, 1st, to this, that the course of the blood being shorter, it has less need of being supported ; and 2d, to this, that the middle part of this system, wanting an agent of impulse, there is no reflux as in the preceding system. In fact, at every contraction, the right auricle sends, as I have said, a portion of its blood into the veins, which resist by the valves. Here, on the

contrary, the course of the fluid is always uniform from one capillary system to the other; there is no cause of retrograde motion.

Remarks upon the motion of the Black Abdominal Blood.

This uniformity in the course of the motion of this black blood, is not merely the result of the absence of the agent of impulse, but also of this, that the liver does not present as many obstacles to it, as the lungs do to the preceding black blood. Observe also that the liver occupies in regard to this system, the same place as the lungs in regard to the other; it is the termination of the circulation of which we are treating. Having no dilatation or contraction, deprived of the fluid which acts incessantly upon the lungs, and which, loaded with different foreign substances, can often alter the vital forces of these organs, so as to interrupt the passage of the blood, &c. The liver, having a solid and granulated substance, in which no extraordinary motion can take place, except those of the general locomotion of the organ, is evidently incapable of frequently interrupting the course of the black blood, which the abdominal system sends there. Add to this the want of the agent of impulse, and you will understand, 1st. why, when the abdomen is open, we never see a pulsation, a reflux in the veins of the abdominal system, as we observe in those of the other system; 2d. why we always find there nearly the same quantity of blood; 3d. why, consequently, we do not discover, either in the common trunk that corresponds to the heart, or in its branches, the numberless varieties of dilatation and contraction, which the right side of the heart, and all the great venous trunks so frequently exhibit, so that scarcely two subjects are alike in this respect, whilst here the arrangement is always nearly the same; 4th. why the liver is not subject to the innumerable varieties in size that the lungs are. This deserves a particular consideration. You will rarely

find the lungs twice containing the same quantity of blood; the weight varies enormously in this respect. Now this arises from the greater or less obstacles the blood has met with in passing through these organs in the last moments of life. We can make them more or less heavy in an animal, by making him die of asphyxia or hemorrhage, consequently by filling with blood, or emptying the extremities of the pulmonary artery. Whatever on the contrary is the kind of death, the hepatic extremities of the abdominal system, contain always nearly the same quantity of blood; suppose, that more remains than usual in this system at the moment of death, it is generally distributed, because there is no agent of impulse, which, at the last moments, drives the greatest quantity to the liver, as happens to the lungs. We understand from this, why the liver exhibits a firm, resisting texture, not extensible like that of the lungs. Sometimes the blood enters it in greater or less quantity, it is even, more or less heavy according to the kind of death. But these varieties belong only to the hepatic veins, which enter into the vena cave inferior just below the heart; they arise from the greater or less reflux of blood that takes place there, as in all the great venous trunks; they consequently arise almost always from the lungs; so that when we see that they are loaded with blood, the right auricle consequently distended, we may also be sure that the liver contains more of this fluid than usual. But this phenomenon, of which I shall speak when treating of the liver, is wholly disconnected with the system which I am describing.

The mechanism of the circulation of the abdominal part of this system, is precisely the same as that of the veins. As to that of the hepatic part, it is unlike that of any other part of the economy. It has no analogy to that of the arteries, for in them the heart is almost every thing, and here there is nothing to correspond to that system; for certainly there is no kind of contraction in the

common trunk of the two trees, as I have been frequently convinced. It is then the same motion, which is continued from the gastric viscera to the liver. There is still much obscurity to be removed concerning this motion, as well as the preceding. Every judicious mind perceives that there is a great void, in reading what has been written upon the motion of the general venous blood, and upon this.

We cannot deny but that external agents do much in this last circulation as in the first. The uniform elevation and depression of the diaphragm, the corresponding motion of the abdominal parietes, the alternate dilatation and contraction of the hollow viscera of the abdomen, the constant locomotion of the small intestines, &c. all these causes certainly have an influence upon the motion of the black abdominal blood; and I even think, that the absence of most of them contributes to retard this motion in the hemorrhoidal veins, and to occasion varices in them.

This influence is not however such as Boerhaave thought, that the circulation could not go on without it. In fact, when the abdomen of an animal is opened, the blood is transmitted the same to the liver, and spouts in the same manner from an open vessel; but we observe a sensible weakness in a short time, and this before the general circulation is enfeebled.

Remarks upon the Liver.

The use of the liver, in being the termination of the black abdominal blood, as the lungs are that of the black blood of all the rest of the body, gives it an importance unknown to all the other secretory organs. Some authors, in observing the enormous size of this viscus compared to the quantity of fluid secreted by it, have suspected that it had another use, besides the secretion of this fluid. This suspicion appears to me, to amount almost to certainty. Compare the hepatic excretories and reservoirs, with the

same parts in the kidnies, the salivary glands, the pancreas even, and you will see that they hardly surpass them, and that they are inferior to those of the first. Then compare the size of the liver with that of the kidnies, of the salivary glands, &c. and you will see the difference. If on the other hand, we examine the bile, voided with the stools which it colours, if we open the intestines at the different periods of digestion, as I have done, to see the quantity of this fluid that is poured out; if we keep an animal without food in order to let it accumulate by itself in the intestines; if we tie the ductus choledochus to retain the bile, &c. it is impossible not to be convinced, that the quantity of this fluid is disproportioned to the size of the liver. This viscus is alone equal in size to all the other glands united ; now, place on one side, the bile, and on the other, all the secreted fluids, the urine, the saliva, the pancreatic juice, the mucous juices, &c. you will see how enormous the difference is.

Since then the secretion of bile is not the only object of the liver, it must have some other use in the economy. What this is we are ignorant; it is however undoubtedly connected with the existence of the system with black blood of which it is the termination, and is especially relative to this system. The following considerations appear to prove that this use is among the most important.

1st. The liver exists in all classes of animals. In those even in which most of the other essential viscera are very imperfect, it is well developed. 2d. Most of the passions affect it particularly, many of them have an exclusive effect upon it, whilst a great number of the other glands hardly perceive them at all. 3d. In diseases, it takes as evident a part as the first viscera in the economy. In many nervous affections, in hypochondria, melancholy, &c. it has a great influence compared to other glands. We know how easily its functions are deranged. It has undoubtedly no connexion with some affections called

bilious, and which are seated exclusively in the stomach, but it certainly has a part in most of them. Since there is no doubt that the jaundice depends wholly upon a serious affection of this viscus, we ought certainly to conclude that the yellow tinge of the face in many of these affections, arises from a cause existing in this viscus, and which is not sufficiently powerful to produce jaundice. Whether in order to produce this tinge, the bile circulates or not with the blood, is of no consequence ; it is incontestible that it is occasioned by affections of the liver; now the numerous cases in which it takes place, prove how much this viscus is often affected ; there is certainly no gland in the animal economy so frequently. 4th. Shall I speak of organic affections? compare in the examination of bodies, those of the liver, with those of all the other organs of the same class, and you will see that there is no one equal to it in this respect ; the kidney approaches it, in the frequency of the alteration of its texture, but it is far from being equal to it. 5th. Who does not know the influence of the liver upon temperaments? Who does not know that its predominance gives to the external appearance, the functions, the passions, the character even, a peculiar shade which the ancients have noticed, and which modern observations have confirmed ? Now see if the other glands have a similar influence in the economy. 6th. The liver is, with the heart and the brain, the organ that is first formed ; it precedes all the other organs in its development; it is incomparably superior, in this respect, to all the glands.

From all these considerations, and from many others that I might add, we may conclude, I think, that the unknown part which the liver performs in the animal economy, besides the secretion of bile, is among the most important. The study of this part, is one of the points most worthy of arresting the attention of physiologists.

It has been said latterly, that the liver corresponded to the lungs in their functions of removing from the blood its hydrogen and carbon. I know not how this fact can be proved by experiment; but I am positive that the liver does not turn the black blood of the abdominal system into red. 1st. The blood of the right auricle is of the same colour as that of the vena cava inferior; now if the blood went red from the hepatic veins, it would certainly give a brighter tinge to that of the auricle. 2d. Having opened the abdomen and thorax of a dog, I tied with a curved needle the vena cava at its entrance into the heart and above the kidney, then by detaching the liver from behind, I cut the portion intercepted between the two ligatures, and where the hepatic veins opened; the blood came out as black as that of the rest of the system. 3d. Tear out the liver of a living animal, examine immediately its veins, you will see that they contain a blood analogous to that of the others. 4th. This viscus, cut in slices in a living animal, pours out behind an analogous fluid, except some small red streams furnished by the last small branches of the hepatic artery; this is wholly different in the same experiment made upon the lungs.

If the black abdominal blood receives any modifications of its nature in the liver, they certainly have no influence upon its colour, its consistence, or sensible qualities.

The general opinion is that the black abdominal blood serves for the secretion of bile, and that the hepatic artery is only destined to nourish the liver; this is what Haller has adopted; I have also admitted it; but I am far from considering it as clearly demonstrated as it has generally been thought to be; the following observations prove, that we ought to consider it as an hypothesis somewhat uncertain.

1st. It is said that the hepatic blood, blacker, more oily, impregnated with the vapours of the excrements, of a bitter taste even, approaches nearer the nature of bile

than the arterial blood, and that it is consequently more proper to form it. I do not know whether this blood has been analyzed comparatively; but I have certainly not found any difference in its external attributes; I did think that in an experiment I observed fatty drops swimming in it; different experiments have convinced me that it was an error. I doubt whether it could ever be demonstrated that the alkaline particles of aliments and of excrements pass into the vena porta; this passage is a gratuitous supposition. 2d. It is said that the volume of the liver is considerable compared to the hepatic artery; this is true; but it is not with the size of this viscus that we should compare that of this artery, to know if it furnishes the materials of secretion, since we have seen that it is impossible that the whole substance of the liver should be destined to secrete bile; it is with the biliary ducts and their reservoir, that we should make the comparison; now this artery is exactly proportioned to these ducts; there is between them nearly the same relation as between the renal artery and the ureter; on the contrary, the biliary ducts are manifestly disproportioned to the vena porta. 3d. It is said that the slow motion in this vein, is favourable to the secretion of bile. But upon what positive data is this assertion founded? Why is slowness of motion more necessary for this secretion than for others? 4th. It is said that the hepatic artery having been tied, the secretion of bile continued. But when we know the relation of parts, the least reflection is sufficient to convince us, that a ligature of this kind cannot be made without producing a derangement that will prevent us from distinguishing any thing. I attempted it once, but could not finish it; I was almost persuaded of it before. 5th. It is said that the black blood is more proper to furnish the materials of the bile than the red. But what is the reason of it? is it because this blood contains more carbon and hydrogen? But it is then the

black blood that furnishes the fat also; now all anatomists are agreed, that it is exhaled from the exhalant extremities of the arteries; the same is true of the marrow, the wax, and in general of all the oily fluids. 6th. A fine injection, made in the hepatic portion of the abdominal system with black blood, passes into the biliary vessels. But a similar passage takes place in an injection from the hepatic artery. 7th. It is said that the black abdominal blood in the spleen has qualities essential to the bile. But the secretion of this fluid can evidently take place without the spleen; many experiments prove this. 8th. It is said that at the instant the vena porta is tied, bile ceases to be secreted; it is undoubtedly less difficult to tie the trunk of this vein below the duodenum than the hepatic artery. How can we examine what is going on in the liver? Do we judge by the fluid flowing from the hepatic duct? But open the duodenum, and you will not very often see the bile running out at the opening of the ductus choledochus, undoubtedly because the air contracts and irritates this duct. This phenomenon, observed after a ligature is applied, is not then conclusive; moreover there does flow towards the time of digestion but too little bile by the ductus choledochus, to be able to estimate it. In fine, what inference can be drawn from an animal whose abdomen is open?

These different reflections prove, I think, that we have not sufficiently direct proofs, to decide whether the secretion of bile is from the abdominal black blood or the red. I do not attribute this function more to one than the other; I say that these things should be subjected to a new examination, and that this example is a proof that the opinions most generally received in physiology, those consecrated by the assent of all celebrated authors, often rest upon very uncertain foundations. We are yet far from the time when this science will be only a series of facts rigorously deduced from each other.

The hepatic artery has been said to resemble the bronchial, and the hepatic vena porta the pulmonary artery; this is true in the general arrangement; but what is the proof of it as it regards the functions? On the contrary, I have proved above that those of the two last vessels are not similar. Let us wait, before deciding, for further and positive researches; let us doubt till then; let us not attribute the secretion of bile to the hepatic artery, nor the vena porta, nor to them unitedly. Certainly it is by one of these three means; but which? what vessel furnishes the secretion of bile? what part does the black abdominal blood perform in the liver, if it is not from it that this fluid is secreted? what, in fine, is the function of the hepatic artery, if it is not connected with this secretion? These are questions to be resolved.

Physicians have also hazarded opinions upon the influence of the black abdominal blood in diseases. Undoubtedly the expression, *vena portarum, porta malorum*, contains a very true meaning; but certainly in the present state of our knowledge, it is, in a strict sense, only a play upon words. If we would express by it the frequency of affections of the liver, it is without doubt just; but if it is employed to express the influence of the vena porta in diseases, it is vague and does not rest upon any positive fact. The more we open dead bodies, the more we shall be convinced, I think, of the necessity of a precise and accurate language, freed from all these ingenious, hypothetical ideas, which do honour, it is true, to their author, but which retard science, by introducing into it a manner of seeing hypothetically, and contrary to the spirit of observation.

Remarks upon the course of the Bile.

Though this question may be to a certain degree foreign to my object, yet as the black abdominal blood has perhaps a real influence upon the secretion of the bile,

as my experiments upon this point determine with precision the course of this fluid, I do not think it useless to relate them here. All that is known further upon the uses, mechanism, &c. of this secretion is to be found in works of physiology, to which I refer.

There has been much discussion to ascertain if there was cystic and hepatic bile, if one was of a different nature from the other, if their quantity increased or varied, &c. Contrary and even opposite opinions have been supported by numerous experiments made upon living animals, as Haller has observed. These experiments, though at first view contradictory, are not so, however, as I was convinced by repeating them at different periods of digestion and during the abstinence of the animal; it had not been done with precision. The following is what I have observed in dogs, which I have used in my experiments.

1st. During abstinence, the stomach and small intestines being empty, we find the bile in the ductus hepaticus and ductus choledochus yellowish and clear; the surface of the duodenum and jejunum tinged by bile which has the same appearance; the gall-bladder much distended by a greenish, bitter bile, much deeper coloured and more abundant if the abstinence has been long. 2d. During digestion in the stomach, which may be prolonged for a length of time, by giving to a dog large pieces of meat, which he swallows without masticating, things are nearly in the same state. 3d. At the beginning of the intestinal digestion, we find the bile of the hepatic duct always yellowish, that of the ductus choledochus deeper coloured, the gall-bladder less full and its bile already becoming clearer. 4th. At the end of digestion and immediately after, the bile of the hepatic duct, of the ductus choledochus, that in the gall-bladder, and that which is found upon the duodenum, are of precisely the same colour as the common hepatic bile, that is, of a clear yel-

low, and a little bitter. The gall-bladder is about half full; it is flaccid, not contracted.

These observations, repeated a great number of times, evidently prove that this, during abstinence and digestion, is the manner in which the flow of bile takes place; 1st, it appears that at all times the liver secretes a certain quantity, which is increased during digestion; 2d, that which is furnished during abstinence is divided between the intestine that is always coloured with it, and the gall-bladder which retains it, without pouring out any portion of it by the cystic duct, and in which, thus retained, it acquires an acrid character and a deep colour, necessary, no doubt, to digestion which is to follow. 3d. When the aliments, having been digested by the stomach, pass into the duodenum, then all the hepatic bile, which was before divided, flows into the intestine, and even in greater abundance. On the other hand, the gall-bladder pours also that which it contains upon the alimentary mass, which is then completely penetrated with it. 4th. After intestinal digestion, the hepatic bile diminishes, and a part begins to flow into the duodenum, and a part to flow back into the gall-bladder, in which, if then examined, it is found clear and in small quantity, because it has had neither time to be coloured or accumulate.

There is then this difference between the two biles, that the hepatic flows almost in a continued manner into the intestine, and that the cystic flows back, except during digestion, into the gall-bladder, and flows, during this function, towards the duodenum; or rather it is the same fluid, of which a part always preserves the same character that it had at its exit from the liver, and the other assumes a different one in the gall-bladder. The diversity of colour in the cystic bile, according as it has been retained long or not, has much analogy to the colour of the urine, which is found more or less deep coloured, as it has been for a longer or shorter time in the bladder.

As to the course of the bile in relation to the stomach, I believe that this viscus contains a certain quantity of it at all times. When empty, we find there a mixture of gastric juices and mucus more or less abundant, sometimes mixed with small bubbles of hydrogen, which burn when brought in contact with flame, and almost always tinged with a yellowish colour from the bile that has flowed up through the pylorus. Haller says that this reflux of bile into the stomach does not always happen; Morgagni says that it always does in men. I have never opened a dog, in whom it has not been seen when the stomach was empty, especially if it had been so for some time. Human dead bodies are not proper to decide this question, because the kind of disease alters almost inevitably the course, the nature, and even the colour of the bile. I shall say in another volume what conclusion we should draw from this, as it respects bilious vomitings.

In a state of fulness, it has sometimes appeared to me impossible to estimate the reflux of the bile; in other states, between the alimentary mass and the parietes of the stomach, I have seen yellowish, gastric fluids; but this mass itself never has this colour.

The bile that flows into the stomach has always appeared to me to be hepatic bile, from its light colour. I think that I have opened a sufficient number of living animals to convince me, that this bile is hardly ever found very green, and that it acquires this colour from the gall-bladder; and that it is this that is brought up by vomiting in some affections. The reflux of this bile appears to be an effect of the affection itself. This observation agrees with that made above, viz. that the hepatic bile alone flows into the duodenum in abstinence. It alone can then, as we may be convinced, flow into the stomach. During intestinal digestion, in which the cystic bile flows, it is evident, that the aliments going continually out of the pylorus, prevent it from passing there and

entering the stomach; that which we find during fulness, was there then, or entered there before the peristaltic motion had begun to evacuate this organ.

When we open the gall-bladder in a dead body, we see that the bile there exhibits, according to its diseases, a variety of shades of colour, from that which is black as ink to a kind of transparent fluid. Ought we then to be astonished, if the vomitings in which the cystic bile is brought up, that has flowed into the stomach against the ordinary course of things, should contain matters of such various colours?

Development.

In the fœtus, the system of black abdominal blood is not insulated; it becomes a part of the two others, by means of the ductus venosus. There is then truly but one vascular system in the fœtus, whilst after birth, there are three separate ones, two with black blood and one with red.

In the fœtus, it is especially with the umbilical vein that the abdominal system with black blood is continued. The liver is a centre, in which both arrive from two different sides, and in which they unite, in a common trunk. The two columns of blood that they circulate, do not meet directly; their course forms a very remarkable angle.

When we examine attentively the orifice of the ductus venosus in the trunk, made by the union of these two veins, we see that it presents itself naturally to the blood of the umbilical vein; that that of the vena porta, on the contrary, cannot enter there. In fact, there is a little fold in the form of a valve, less evident, it is true, than many others, but yet existing. This fold is only a kind of projection, placed between the end of the vena porta and the ductus venosus, and which contracts the orifice of this, so that it is evidently narrower than the

caliber of its own canal. The blood coming from the vena porta and passing at the side of this fold, presses it against the orifice, and thus forms an obstacle; that coming from the umbilical vein, falling, on the contrary, perpendicularly on this orifice, removes this fold, and enters the canal.

It hence follows that the ductus venosus is evidently destined to carry to the vena cava the residue of the blood of the umbilical vein; I say the residue; in fact, as this vein is very large and the ductus small in proportion to it, it is evident that the greatest part of the blood penetrates the liver, by the different ramifications that enter its substance.

The abdominal vascular system is less developed in the fœtus than afterwards; it consequently carries less blood to the liver; this is the same arrangement as in all the other veins. I would observe, that the small quantity, however, which the liver receives in this way, is more than compensated by that of the umbilical vein. This viscus is, then, habitually entered in the fœtus, by a greater quantity of fluid than at any of the other ages. Hence, 1st, why its nutrition is so developed and its size so great; 2d, why it is, in proportion to its size, heavier than in the after ages; 3d, why when we cut it in slices, there flows out a greater quantity of blood; 4th, why, when we dry slices of the liver of a fœtus, of the same thickness as others taken from the liver of an adult, and especially of an old person, they are reduced to a less size.

The disproportion of the size of the liver of the fœtus is more evident, the sooner it is examined after conception; this is the same as with the brain. As the fœtus advances towards birth, the liver approximates in its proportions to the other organs, that which it will have in the adult. From the observations of Portal, it is especially till the seventh month, that the liver is predominant. This circumstance appears to arise from this, that the

umbilical vein transmits as much more blood in proportion to the fœtus, as it is less advanced in age.

At this age, the blood of the umbilical vein and that of the vena porta evidently mix, at least in a great measure, in the common trunk. Is their nature analogous? There is no experimental knowledge upon this point. But Baudelocque has many times observed that that of the umbilical vein is redder, and even approximates the nature of arterial blood. I have not accurately observed this fact in any animals except guinea pigs, in whom the want of transparency in the cord does not allow us to see a great difference in the blood of the arteries and of the umbilical vein; but this difference can be in fact more evident in man; now, in this case, the umbilical blood appears to lose this redness in the liver, for very certainly it is uniform beyond this viscus in the circulation of the fœtus, as I have often ascertained.

At the period of birth, the blood ceasing to come by the umbilical vein, the liver becomes only the termination of the black abdominal blood. Then a kind of revolution takes place in this viscus. The different tubes that carried to it umbilical blood do not close up, but they transmit exclusively that of the vena porta, which increases a little in size, because digestion, which begins in the gastric organs, calls to them more arterial blood, and consequently more is returned by the veins. This slight increase does not compensate for the absence of the umbilical blood; thus the liver diminishes proportionally in size in an evident manner.

As to the ductus venosus, it is obliterated by the effect of the contractility of texture. The blood coming in the vena porta, has not, as I have said, any tendency to pass through it, because this canal is not in its direction; it passes rather into the hepatic vessels, and the circulation of the liver is established then, as it will always continue to be.

This then is the difference that birth brings to the hepatic circulation; 1st, less blood and only one kind entering the liver; 2d, an interruption of all communication between the general and abdominal black blood; 3d, proportional diminution of the size of the liver. Hence there is an inverse phenomenon for this organ and for the lungs. The latter increases, the other diminishes in activity and size.

The great quantity of blood that enters the liver before birth, and the size of this organ, compared to the small quantity of bile that escapes from it, are an evident proof then that it is destined for other uses besides the secretion of this fluid. There cannot be a doubt upon this point; it is a proof moreover, that in the adult the disproportion of the organ to the fluid, though less sensible, supposes also in it another important function of which we are ignorant.

There ought to be a precise relation between the obliteration of the ductus venosus, of the foramen ovale and the ductus arteriosus, between the increased activity of the lungs and the diminished activity of the liver at birth, &c. We judge of this relation, without knowing it, because a veil is still spread over the circulation of the fœtus. I would only observe that the predominance of the liver before birth, does not suppose any in the system of black abdominal blood; it arises exclusively from the umbilical vein; thus the proportional volume of this organ is constantly diminishing afterwards, especially on the left side, where this vein is distributed, as Portal has observed. It is difficult to name the period, at which the equilibrium is generally established.

In youth, the abdominal system of black blood, like the general, is weak. It is towards the thirtieth or fortieth year, that it seems to be in its greatest activity; this is the age of gastric diseases, of hemorrhoids, and of melancholy, which is connected with the state of the liver.

In old age, the dilatation of the system of black abdominal blood is much less sensible than that of the preceding system; its vessels have nearly the same caliber as in the adult age; which supposes a less diminution in the velocity of the course of its blood, from the principles established above. It never becomes the seat of any kind of osseous incrustation, a phenomenon that evidently assimilates its common membrane to that of the veins, and distinguishes it in a peculiar manner from that of the arteries.

END OF VOL. I.